Feasibility of Reintroduction of the Greater Prairie-Chicken to Neal Smith National Wildlife Refuge

Note: All text bounded by quotations and ended by a reference to Walk 2004, is directly taken from "A Plan for the Recovery of the Greater Prairie-chicken in Illinois".

I. Introduction

The Greater Prairie-Chicken (*Tympanuchus cupido pinnatus*), is referred to as "the signature bird of the tallgrass prairie" by Dr. Jeffrey Walk, who notes that prior to European settlement, the distributions of this species and extent of the ecosystem were "essentially identical" (Figure 1).

Figure 1. Range of the Greater Prairie-Chicken in 1800.
Adapted from various sources – see text.

Prairie-chickens were extirpated from Iowa in the 1950's, but have been successfully introduced in a few areas in southern Iowa (Dinsmore 1994, Moe 2002). Prairie-chickens rank as a high conservation priority throughout their range particularly because their populations continue to decline (Walk 2004). "The charismatic breeding displays of prairie-chickens help to garner broad-based public support for conservation efforts. Further, Greater Prairie-Chickens have large home ranges and require a variety of grassland habitats throughout the year. For these reasons, the Greater Prairie-Chicken is an excellent "umbrella species" for prairie conservation; regimes that sustain prairie-chickens are likely to encompass the needs of numerous other species that require smaller areas or fewer habitat resources" (Walk 2004).

The ecological goal of Neal Smith National Wildlife Refuge (NSM) is to emulate the historic natural landscape as nearly as possible on 8,654 acres, including vascular plants, vertebrates, invertebrates, micro-organisms, as well as soil and water characteristics. The Master Plan for NSM (formerly Walnut Creek National Wildlife Refuge) indicates that though prairie-chickens have been extirpated from southern Iowa since the 1950's, it should be considered for reintroduction to the refuge (U.S. Fish and Wildlife Service 1992). The document further indicates that due to adjacent land management, success in introducing prairie-chickens may be limited by lack of suitable habitat beyond the refuge borders, and by competition with ring-necked pheasant. Many prairie bird species have found their way to the refuge, and more can be expected to as prairie habitat matures. Dinsmore (1994) states, however, that "there is little likelihood that a population [of prairie-chickens] will get established in the state [of Iowa] by natural means". As such, without a nearby established flock, prairie-chickens will need to be introduced to the refuge.

The objective of this document is to investigate feasibility of introduction of prairie-chickens to NSM at this time. This includes developing an understanding of the habitat, refuge management, refuge resource, and partnership needs to accomplish the task. Also critical, is developing an understanding of timing for prairie-chicken introduction within the context of ecological restoration.

II. Taxonomy

"The Greater Prairie-Chicken, *Tympanuchus cupido*, is a species of grouse native to the tallgrass prairies of North America. Other common names for this bird are Pinnated Grouse, Prairie Grouse, and Prairie Hen. Two other extant species are in the genus *Tympanuchus*. The Sharp-tailed Grouse, *T. phasianellus,* is found in the northern Great Plains and Canada, and the Lesser Prairie-Chicken, *T. pallidicinctus,* occurs in the southern Great Plains. There are three subspecies of Greater Prairie-chicken. The Heath Hen, *T. c. cupido,* occurred in coastal New England grasslands, but became extinct in 1932. Attwater's Prairie-Chicken, *T. c. attwateri*, is Federally endangered and occurs on the coastal prairies of Texas. The Greater Prairie-Chicken, *T. c. pinnatus,* exists in 11 states in the Midwest & Great Plains (Schroeder and Robb 1993, Westemeier and Gough 1999). *T. c. pinnatus* is the taxon occurring in Illinois, although Sharp-tailed Grouse were present in northern Illinois prior to 1870 (Bohlen 1989)" (Walk 2004).

III. Description

"Greater Prairie-Chickens are medium-sized grouse (420-470 mm total length), slightly larger than Sharp-tailed Grouse and Lesser Prairie-Chickens, and smaller than Ring-necked Pheasants. Males and females are nearly identical in plumage, which is extensively barred with brown, buff and black. The abdomen is buffy, and the undertail coverts are whitish. Tarsi are feathered to the toes. The tail is short, rounded, black in

males, and black barred with light brown in females. Both genders have tufts of elongated feathers on the side of the neck (*pinnae*), but pinnae are considerably longer in males (70 mm) than females (38 mm). Males possess conspicuous yellow combs above the eyes and yellow-orange, scarlet-edged esophageal air sacs (*tympani*) on the sides of the neck that are exposed and expanded during breeding displays. Males generally weigh 900 to 1,100 g, and females 750 to 950 g (from Johnsgard 1983 and Schroeder and Robb 1993)" (Walk 2004).

IV. Status

A. Historical Occurrence

North America. "Prior to extensive European settlement, the Greater Prairie-Chicken is presumed to have occurred in suitable open, tallgrass prairie habitats extending from eastern Indiana westward to roughly the 100th meridian, and from southern Minnesota, southward to northeast Texas (Schroeder and Robb 1993; Svedarsky et al. 2000; Figure 1). There is little evidence of the abundance of Greater Prairie-Chickens on the eastern tallgrass prairie in prehistoric times, but populations were likely dynamic in space and time, responding to particular habitat conditions created by fire, grazing, drought, and succession (Westemeier 1985).

As European settlement cleared eastern and northern forests, introduced high-energy grains to landscapes, and decimated the herds of bison (*Bison bison*) on the Great Plains, the Greater Prairie-Chicken increased tremendously in range and abundance. The prairie-chicken range extended from Ontario and Ohio westward to eastern Colorado, and from central Texas northward to central Alberta (Schroeder and Robb 1993; Svedarsky et al. 2000), (Figure 2).

Peak abundance of Greater Prairie-Chickens followed settlement to the west and north; peak abundance was circa 1860 in Illinois, 1880 in Iowa, and early 1900s in Colorado and southern Canada (Westemeier and Edwards 1987, Hjertaas et al. 1993, Svedarsky et al. 2000). After this period of expansion, the range and abundance of prairie-chickens contracted as grasslands were extensively converted to cropland and utilized more intensively" (Walk 2004).

Iowa. Greater Prairie-Chickens were common throughout most of Iowa at the time of settlement by Euro-Americans (Dinsmore 1994, Ehrsman, 1996), though apparently uncommon in Northwestern Iowa (Kent and Dinsmore 1996). The process of conversion of native landscapes to farmed landscapes was favorable to prairie-chickens in the initial decades of agricultural development. (Dinsmore 1994, Ehrsman 1996). "A checkerboard of cropped land with high energy grains, interspersed with hayland, pastures and native prairie resulted in habitat probably ideal in providing food, winter and nesting cover, and open areas for leks. Prairie-chicken numbers peaked in the 1870's to 1880's under these conditions" (Walk 2004).

Figure 2. Range of the Greater Prairie-Chicken in 1900.
Adapted from various sources-see text.

Some prairie-chicken populations were apparently migratory as reported by observers in the late 1800's. The annual flight pattern of thousands of prairie-chickens migrating southeast in fall, and northwest in spring indicated that the source populations of these birds was Minnesota and the Dakotas (Dinsmore 1994). Flocks of 200-300 resident and migrant prairie-chickens gathered in winter in Iowa to feed in corn stubble and old grain fields. Extrapolating numbers reported in 1884 near Charles City, one flock may have had as many 33,000 birds (Dinsmore1994).

B. Current Status & Abundance

North America. "Greater Prairie-Chicken population trends are fairly well-monitored by surveys of leks in spring. By measuring males/lek, lek density, or male density, population trends are estimated. In many cases, the small, fragmented range of the species allows a more-or-less complete census of males in entire regions or states (see Svedarsky et al. 1999a). Further, range-wide status evaluations have been made at roughly 10-year intervals (Christisen 1969, Westemeier 1980, Gough 1990, Svedarsky et al. 2000).

Greater Prairie-Chickens have been extirpated from Canada (Hjertaas et al. 1993), but still exist in 11 states (Figure 3).

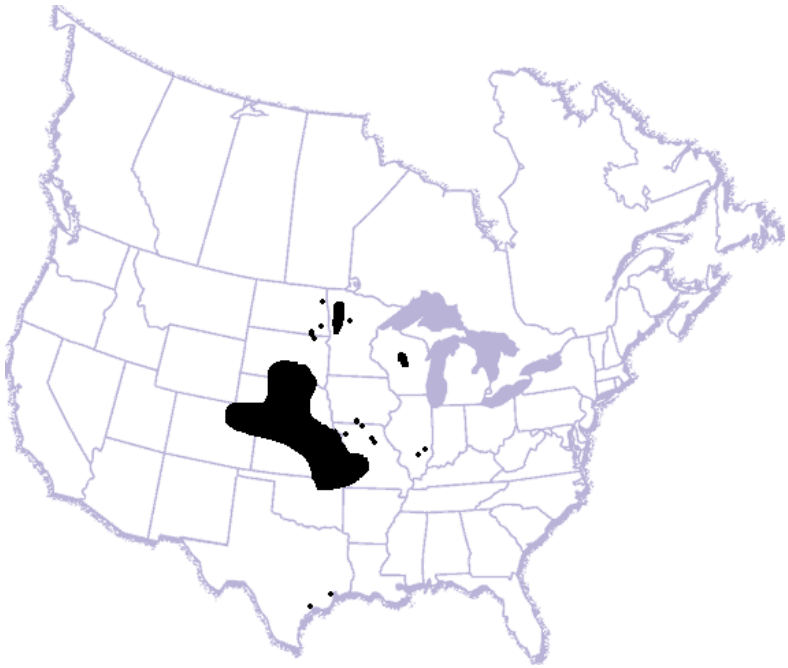


Figure 3. Range of the Greater Prairie-Chicken in 2000.
Adapted from various sources-see text.

Hunted populations exist in Colorado, Kansas, Minnesota, Nebraska, and South Dakota; modern annual harvests are around 50,000 birds (combined; from Johnsgard 2002). The species is listed as state threatened in North Dakota and Wisconsin, and state endangered in Illinois and Missouri (Svedarsky et al. 1999a). The estimated global population of Greater Prairie-Chickens has declined from 1,079,000 in 1968 to 391,000 in 1997 (from Westemeier and Gough 1999)" (Walk 2004).

Iowa. Prairie-chickens were extirpated from Iowa in the 1950's. At present, a few leks exist in southern Iowa after extensive reintroduction efforts by the Iowa Department of Natural Resources (Iowa DNR) since 1980 (Moe 2002).

C. Reasons for Current Status

Hunting and trapping. Prairie-chicken were easy to trap and hunt, and in Iowa, massive numbers of them were killed for sport and market hunting and as food for local settlers. In 1864, three train carloads were shipped to Chicago from Marshalltown at a price of two dollars per dozen. A company in Waterloo shipped 3,600 prairie-chickens to the East Coast in winter of 1871-1872 (Dinsmore 1994). Various laws were enacted in Iowa to limit prairie-chicken hunting season and bag limits beginning in the 1856-1857 legislative season. These laws, however, were poorly enforced, especially after prairie-chickens were perceived as agricultural pests. In 1917, hunting prairie-chickens in Iowa was finally legally halted (Dinsmore 1994).

***Habitat loss and degradation*.** Dinsmore (1994) notes that despite extreme hunting and trapping, prairie-chickens may have survived in Iowa had suitable habitat remained. However, continued expansion of farmland resulted in critical loss of thick, rank nesting habitat. Good nesting and winter cover formerly supplied by marshland became increasingly scarce as tiling and drainage of the landscape increased. In addition, spring haying in areas attractive as nesting habitat killed many prairie-chickens and destroyed their nests. In recent decades, arthropod populations have been greatly reduced in agricultural areas due to extensive use of agrochemicals. The reduction in arthropods has been implicated as a reason for reduction in survival of Ring-necked Pheasant chicks, which are ecologically similar to prairie-chickens (Basore et al. 1987, Warner et al. 1999 in Walk 2004).

A common practice of burning in spring by farmers in attempts to remove duff to control grasshoppers also was a threat to prairie-chickens, as many nests were destroyed by the fires. A farmer near Spirit Lake counted as many as thirteen dozen eggs after a fire in 1885 (Dinsmore 1994).

Prairie-chicken mortality also increased from collisions with utility and barbed wire. This was exacerbated because prairie-chickens have a low flight pattern. The combination of habitat loss, and combined pressures of aggressive hunting and trapping, fire, and mortality from collisions with wires resulted in the demise of the prairie-chicken in Iowa (Dinsmore 1994)

Even after hunting was stopped in 1917, numbers of prairie-chickens continued to decrease. Only about 100 nesting pairs remained in the 1930's near Wayne and Appanoose counties, with a few in Spirit Lake and possibly isolated birds elsewhere. Though populations fluctuated from year to year, by 1952, only 10 were estimated to be in Appanoose County, and by 1955, only one (Dinsmore 1994).

Ring-necked Pheasants. " Extirpation of Greater Prairie-Chickens from many areas in the early 20th century actually pre-dated the elimination of suitable grassland habitat. These local extinction events were often correlated with the local establishment of Ring-necked Pheasants (Calahane et al. 1942, Sharp 1957 in Walk 2004). Ring-necked pheasants were introduced to Iowa in 1900, and have become the most common upland game bird in the state. Prairie-chickens compete poorly with the more aggressive pheasant that often lays eggs in nests of prairie-chickens or disrupts courtship on leks (Dinsmore 1994). In studies on Prairie Ridge State Natural Area (PRSNA) in Illinois, it was found that "pheasant eggs require about 23 days of incubation to hatch, versus about 25 days for prairie-chicken eggs. In several instances, prairie-chicken hens incubated mixed-species clutches until the pheasant eggs hatched, and abandoned many or all of their own eggs prior to hatching. Greater Prairie-Chicken nests containing pheasant eggs suffer lower egg success and higher abandonment than unparasitized nests (Westemeier et al. 1998c)" (Walk 2004).

Nest & brood predators. In agricultural areas, mid-sized mammalian predators are abundant and often more successful in proximity to human activity because more den

sites and food sources are present. Such predators destroy large numbers of prairie-chicken (R. Westemeier, unpublished data in Walk 2004). Removal of trees in otherwise suitable habitat is the single most important change in improving areas for prairie-chicken habitation in southern Iowa (M. Moe 2004, personal communication).

Genetic inbreeding & Demographic constraints. Small isolated flocks of prairie-chickens can suffer inbreeding depression through time. In Illinois, fitness, "as indexed by egg success, dropped from 91-100% in the 1960s to 38% in 1990 (Westemeier et al. 1998a). Bouzat et al. (1998b) showed that Greater Prairie-Chicken samples collected in Illinois after 1974 were genetically impoverished compared to samples from Kansas, Minnesota and Nebraska, and compared to samples collected in Jasper County, Illinois, in the 1930s and 1960s. In 1994, <50 prairie-chickens remained in Illinois, suggesting demographic constraints (such as imbalanced gender ratios and the amplified importance of individual dispersal, mortality and nest failure events, due to small population size) were as threatening to the remnant populations as genetic inbreeding" (Walk 2004).

In southern Iowa introductions, Moe (2004, personal communication) feels that inbreeding depression may be ameliorated for the time being by the proximity and genetic make-up of several prairie-chicken populations including a major population at Dunn Ranch in northern Missouri. Moe notes that there is interaction amongst these populations, and that they resulted from various introduction years and sites in Kansas, and thus from different genetic lines (M. Moe 2004, personal communication).

Disease. Prairie-chickens can become diseased as a result of contact with diseased domestic or wild birds. Contact with chicken manure near an egg production facility has been implicated in a marked decline in prairie-chickens displaying at PRSNA in Illinois. Because prairie-chickens and waterfowl both use agricultural fields for foraging, prairie-chickens may become infected by avian cholera and other diseases of waterfowl if diseased birds are present in such areas (Walk 2004).

D. Reintroduction History in Iowa

Note: The following summary of the history of reintroduction of prairie-chickens in Iowa, and status as of 2003 is authored by Mel Moe and directly taken from the Trends in Iowa Wildlife Population and Harvest report published by the Iowa Department of Natural Resources.

"First Reintroduction Attempt. In the early 1980's, the Iowa Conservation Commission, now the Iowa Department of Natural Resources (IDNR), attempted to restore prairie chickens to west central Iowa. The IDNR negotiated with the Kansas Fish and Game Commission (KFGC), now Kansas Department of Wildlife and Parks (KDWP), to trade wild turkeys for 100 prairie chickens (Table 1).

Table 1. Dates, numbers, and locations of greater prairie chicken releases in Iowa, 1980-2001.

Release Date	No. Released	Source*	Release Location
February 1980	29♂ 24♀	KFGC	Loess Hills Wildlife Area, Monona Co.[1]
April 1982	31♂ 18♀	KFGC	Loess Hills Wildlife Area, Monona Co.
April 1987	20♂ 9♀	KFGC	Ringgold Wildlife Area, Ringgold Co.[2]
April 1988	48♂ 75♀	KFGC	Ringgold Wildlife Area, Ringgold Co.
April 1989	40♂ 62♀	KFGC	Ringgold Wildlife Area, Ringgold Co.
April 1992	18♂ 21♀	KDWP (IDNR trapping crew)	Mount Ayr, Ringgold Co., Price Twp., Sec. 13.[3]
April 1992	31♂ 20♀	KDWP (IDNR trapping crew)	Kellerton, Ringgold Co., Athens Twp., Sec. 8.[4]
April 1992	9♂ 9♀	KDWP (IDNR trapping crew)	Ringgold Wildlife Area, Ringgold Co., Lotts Creek Twp., Sec. 24.[2]
April 1993	13♂ 33♀	KDWP (IDNR trapping crew)	Kellerton, Ringgold Co., Athens Twp., Sec. 8.[2]
April 1993	24♂ 24♀	KDWP (IDNR trapping crew)	Orient, Adair Co., Lee Twp., Sec. 36.[5]
April 1994	10♂ 17♀	KDWP (IDNR trapping crew)	Kellerton, Ringgold Co., Athens Twp., Sec. 8.[4]
April 1994	31♂ 34♀	KDWP (IDNR trapping crew)	Orient, Adair Co., Lee Twp., Sec. 36.[5]
April 2001	1♂ 2♀	SDGFP	Kellerton, Ringgold Co., Athens Twp., Sec. 16.[4]

* KFGC = Kansas fish and Game Commission, KDWP = Kansas Department of Wildlife and Parks, SDGFP = South Dakota Game Fish and Parks Department, IDNR = Iowa Department of Natural Resources.

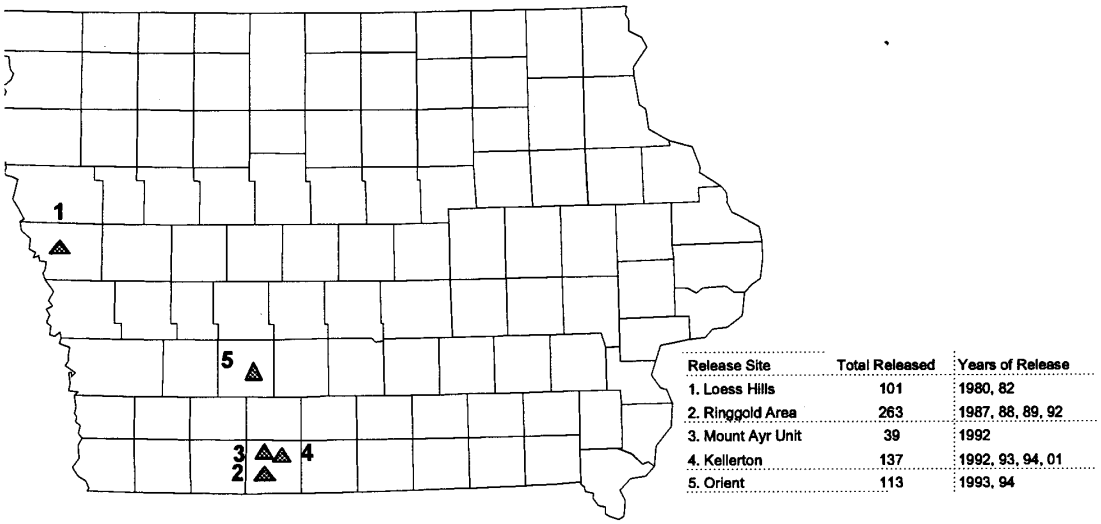
Release sites indicated on county map (Figure 4).

The release site was located in the Loess Hills east of Onawa, Monona County (Figure 4). This is an area of steep to moderately rolling bluffs and hills bordering the Missouri River Valley. These hills have large expanses of grassland interspersed with brush and small crop fields.

Fifty-three prairie chickens were released in 1980. Results from the first release were mixed. A large number of chickens was observed in the release area the following day; however, sightings thereafter were sporadic and often at a distance from the released area. During 1980, reliable sightings were reported both near the release area and up to 19 miles away. The KFGC was unable to secure additional birds for stocking in 1981; however, observations continued. In 1981, single birds occurred near the release

area and groups of birds were reported 20 and 60 miles from the release site. No spring leks were located in the 2 years following the release, and no reproduction was reported.

Figure 4. Location of release sites and total number of prairie chickens released in Iowa, 1980-2001.



Release Site	Total Released	Years of Release
1. Loess Hills	101	1980, 82
2. Ringgold Area	263	1987, 88, 89, 92
3. Mount Ayr Unit	39	1992
4. Kellerton	137	1992, 93, 94, 01
5. Orient	113	1993, 94

Two prairie chicken broods were reported near the release site in 1982, and up to six adults were observed near the Missouri River bottom the same year. Two leks consisting of only a few displaying males were located in 1983 and 1984. Most sightings were in the heavily agricultural Missouri River valley instead of the hills where they were released. The birds appeared to prefer the level valley to the hilly region where they were released. Suitable grassland habitat was lacking in the valley. Only an occasional sighting has been reported in this region since 1984, leading to the conclusion that this reintroduction effort failed (Ron Munkel, IDNR, pers. comm.).

Second Reintroduction Attempt. 1987-1989 Stockings: In 1987, the IDNR made a second restoration attempt. The release site was on the Ringgold Wildlife Area located two miles north of the Missouri border in Ringgold County in south central Iowa (Fig. 8.1). Wildlife personnel considered this region to be the best potential prairie chicken habitat in Iowa. The immediate vicinity was one of the last strongholds of prairie chickens in southern Iowa and northern Missouri (Christisen 1985, Stempel and Rodgers 1960). The surrounding portions of Ringgold County and adjacent Harrison County, Missouri, are cattle country, with 60% or more of the land in permanent grass. Donald Christisen (1985) concluded that the demise of the prairie chickens in this area was due to heavy utilization of grasslands by livestock, resulting in poor quality habitat. Recent years had brought some positive changes in the grasslands of the area. It was hoped that these changes would again provide suitable habitat for prairie chickens. A major change was restoration of around 200 ha of prairie on the Ringgold Wildlife Area. Other changes were better pasture management by some area farmers and the

Conservation Reserve Program (CRP). CRP converted thousands of hectares of cropland into a diversity of mostly undisturbed grasslands for at least 10 years.

The birds for this reintroduction were again obtained from Kansas through a three-way trade in which IDNR supplied wild turkeys to the Michigan Department of Natural Resources (MDNR) while a MDNR crew trapped prairie chickens in Kansas for translocation to Iowa. A total of 254 prairie chickens was translocated to the Ringgold Wildlife Area from Kansas during 1987, 1988, and 1989 (Table 1).

By the spring of 1988, leks had been established at the release site and a site 15 km south in Missouri. The Missouri site was on the Dunn Ranch, a cattle ranch operated by Forrest and Maury Meadows of Bethany, Missouri. The ranch included about 500 ha of well managed native prairie pasture in addition to several hundred hectares of cool season pasture. This ranch contained a major lek before the disappearance of prairie chickens in the 1960's. The lek established in 1988 was on the same site as the historic lek, and the birds using it were verified as Iowa release birds by the bands on their legs (Maury Meadows, pers. comm.).

No prairie chickens were released in 1990 or 1991. Reproductive conditions for gallinaceous birds were poor in this area throughout that time; however, brood sightings were made each year. By 1991, prairie chickens appeared to be firmly established on the Dunn Ranch, but only one lek of six males could be located in Iowa that year. The success of the reintroduction of prairie chickens to the Dunn Ranch was the bright spot of the project thus far. It was evident that reintroductions in this region could succeed.

1992-94 Stockings: Based on the success of the Dunn Ranch, the IDNR continued the restoration program with more translocations from Kansas. An agreement with KDWP allowed IDNR crews to trap and translocate 100 prairie chickens a year. Instead of releasing all of the birds at one site, it was decided to release significant numbers on large grassland tracts in the region, while releasing a smaller number at the original Ringgold Wildlife Area. Birds were translocated to two new sites in 1992, Mount Ayr and Kellerton (Figure 4). The Mount Ayr site is 28 km northwest and the Kellerton site is 24 km northeast of the Ringgold Wildlife Area. The Mount Ayr site was dropped in 1993, and the Orient site was added. Orient is 90 km northwest of the Ringgold Wildlife Area. All of the sites contained high quality grasslands and open landscapes. Most land use at all three sites was a mixture of pasture, hay, and CRP.

A total of 304 prairie chickens was released in this three-year period (Table 1). Gentle releases were made onto either artificial leks or actual leks.

Subsequent Stocking: No additional stockings were anticipated following releases in 1994. However, while live trapping Sharp-tailed Grouse for IDNR's restoration project in the Loess Hills, South Dakota Game Fish and Parks (SDGFP) employees incidentally trapped three prairie chickens in 2001. Rather than release these birds at the trap site, SDGFP offered them to IDNR. The offer was accepted, and one male and two female chickens were released at the Kellerton lek in April 2001. This additional release results in a total of 561 prairie chickens translocated to Iowa since 1987.

Missouri Reintroduction: The Missouri Department of Conservation (MDC) has been reintroducing prairie chickens in north central Missouri since 1993. Approximately 100 birds have been released each year through 1997 and again in 2000. They have released birds at eight sites located 60 to 100 km southeast of the Ringgold Wildlife Area and 10 to 40 km south of the Iowa border (Larry Mechlin, MDC, personal communication).

There were sightings of prairie chickens immediately south of the Iowa border in the spring of 1998, and it is probable that adjacent areas in Iowa have prairie chickens as a direct result of Missouri's stocking efforts. Jeff Telleen and Bruce Fistler picked up a road-killed prairie chicken in Monroe County just south of Melrose on June 7, 1998. The bird was not banded and was mostly likely a pioneering bird from one of Missouri's latest releases. Thunderbird Lake, Missouri, is the release site closest to Melrose. Missouri's releases at Thunderbird Lake are very close to the Iowa border and may act as repayment for Iowa's 1987 releases that reestablished birds on the Dunn Ranch (Larry Mechlin, MDC, personal communication).

Booming Ground Surveys in Iowa. Attempts are made each spring by IDNR personnel and volunteers to locate leks and count booming males. Counts of known leks are made on sunny mornings with winds <10 mph throughout the month of April. Leks sites are glassed or flushed to determine the number of booming males. New leks are located by driving gravel roads and stopping periodically to listen for booming. Because of the large area of potential habitat and limited manpower, the number of booming males observed is considered minimal. It is highly probable that a number of booming grounds have not been located. MDC personnel make similar counts on and around the Dunn Ranch, where the birds are part of the same regional population.

Results. 1995: The number of booming grounds increased from three in 1994 to seven in 1995 with 40 males present (Table 2).

These seven lek sites are found in five different counties. Two of these counties are release site counties (Ringgold, Adair). The lek sites in Adams, Decatur, and Union Counties are birds pioneering new areas. Adult males have a strong affinity for established leks, whereas young males may actively look for new areas to establish a lek. Young females may also wander in the spring in search of a lek. A mosaic of leks across a large area may prove to be an important component of prairie chicken biology.

1996: In the spring of 1996, six leks from 1995 still showed some activity. Note in table 2 that 18 males were observed on four leks, but no legal description was taken. The number of booming males declined 38% from 40 to 25 birds (Table 2). Similar to prairie chickens, pheasant numbers in the southern pasture region declined 31 during this same time. Nesting conditions during the spring and summer of 1995 were abnormally wet. Southern Iowa experienced rainfall totals for April and May 6 inches above normal. This likely reduced nest success in 1995, leading to the reduced number of booming males in 1996.

Table 2. Location and number of greater prairie chickens observed on active leks in Iowa, 1995-2003.

		Legal Description			Number of Booming Males[a]								
County	Township Name	Twp.	Rge.	Sec.	1995	1996	1997	1998	1999	2000	2001	2002	2003
Adair	Orient	74N	31W	3	8	4	2						
Adair	Orient	74N	31W	11	3		3						
Adair	Lee	75N	31W	26				1					
Adams	Union	72N	32W	24	1				3				
Decatur	High Point	69N	24W	1				8					
Decatur	High Point	69N	24W	2	5	3	4[b]					4	
Decatur	High Point	69N	24W	11				1	1				
Decatur	Franklin	70N	25W	9				2					
Decatur	Franklin	70N	25W	20	2	2	1						
Decatur	Garden Grove	70N	24W	36				10	6	7	4		3
Ringgold	Athens	68N	28W	4	14	18[c]	8	5	5	3	1	2	
Ringgold	Athens	68N	28W	16	7		5	12	11	14	11	10	10
Ringgold	Athens	68N	28W	17									5
Ringgold	Athens	68N	28W	2								1	
Ringgold	Athens	68N	28W	20									2
Ringgold	Poe	68N	29W	?					2				
Ringgold	Rice	68N	30W	24				1					
Ringgold	Rice	68N	30W	13							3	2	1
Ringgold	Liberty	69N	29W	3					4		5		4
Ringgold	Liberty	69N	29W	10						8			
Ringgold	Monroe	69N	28W	2							1		
Ringgold	Monroe	69N	28W	12						7			4
Ringgold	Monroe	69N	28W	28					7				
Ringgold	Monroe	69N	28W	33				3					
Ringgold	Monroe	69N	28W	15								1	
Ringgold	Monroe	69N	28W	22									1
Union	Spaulding	73N	31W	?	1								
Wayne	Jackson	68N	21W	18						5	3		2
Wayne	Jackson	68N	21W	14								2	
Total Booming Males[d]		mean=	36.4		40	25	18	43	39	44	28	22	32
Total Active Leks		mean=	7.8		8	3	5	9	8	6	7	7	9
Total Males/Lek		mean=	5.6		5.0	8.3	3.6	4.8	4.9	7.3	4.0	3.1	3.6

[a] underlined numbers indicate birds were observed, but not booming.

[b] Four males were confirmed booming, but may be as many as 7.

[c] Total of 18 males observed on 4 leks but no legal descriptions reported.

[d] Males not observed booming are not included in totals.

1997: Only Ringgold and Decatur Counties had active leks during the spring of 1997, which is a significant decrease from the five counties with active leks in 1996. The decline in lek sites may have been a result of land coming out of CRP. One lek site in Adair

County was plowed in 1996. There was still activity at this site in 1996: however, no birds were observed booming at this location in 1997. In addition to Adair, there were observations of non-booming chickens in Adams, Warren, and Union Counties during spring 1997. Warren was a new county for prairie chicken reports and is somewhat isolated from source populations. This may be indicative that more birds are out there than are being reported.

Final counts showed the number of booming males had declined even further in 1997 (-28%), with 18 males counted on four active leks (Table 2). Another abnormally wet spring in 1996, combined with the loss of CRP, contributed to decreasing prairie chicken numbers. Rainfall across the prairie chicken restoration area averaged 5 inches above the long-term average. Pheasant counts across southern Iowa also declined >30% during this time. The decline in booming males could again be attributed to poor reproductive success during 1996, with the loss of several leks sites in Adair County aggravating the problem of poor recruitment.

1998: Department personnel observed booming activity in Adair, Decatur, and Ringgold Counties in 1998. Forty-three males were observed on nine leks (Table 2). This represents a 139% increase in the number of booming males and a 125% increase in active leks over 1997. Upland bird nesting conditions greatly improved across southern Iowa in 1997, as evidenced by a 60% increase in pheasant numbers during 1997. Mel Moe reported the first prairie chicken brood on June 6, 1998: a brood of 12 in Section 33, Monroe Township, Ringgold County

1999: Department personnel observed booming activity in Adams, Decatur, and Ringgold Counties in 1999. Thirty-nine males were observed on eight leks (Table 2). This represents a 9% decrease in the number of booming males and 11% decrease in active leks over 1998. Due to the abnormally wet nesting season in south central Iowa last year, pheasant counts were at an all time low for the region. The fact that prairie chicken numbers remained essentially unchanged from 1998 is a very positive sign for Iowa's population. The location of known active leks is shown in Figure 5.

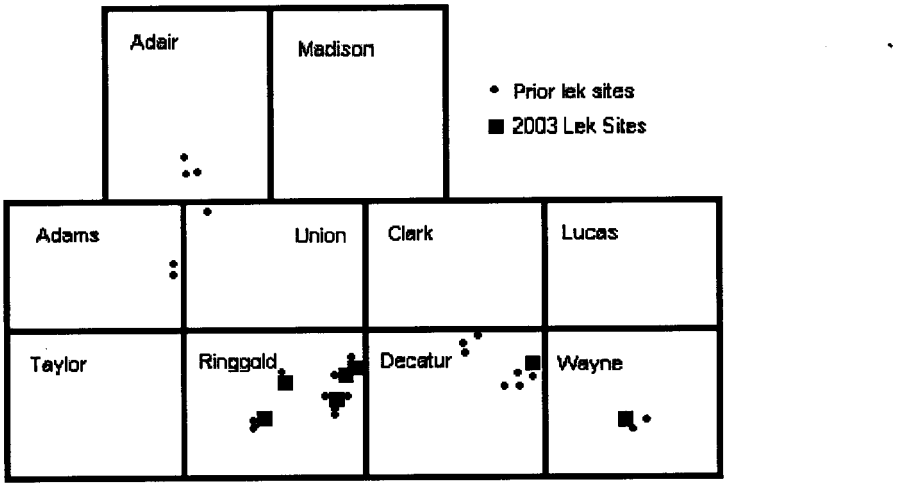
2000: Booming prairie chicken males were observed in Decatur, Ringgold, and Wayne Counties in 2000 (Table 2). This was the first time a lek was recorded in Wayne County. Forty four males were active on six booming grounds. This was the highest number of booming males recorded in Iowa and the highest total number of males per lek. The number of booming males increased 13% over 1999, but the number of active leks decreased from eight to six (-25%). The six-year mean total number of booming males is 34.8; therefore, the number observed in 2000 is 26% above the mean. The same trend was observed for total number of males per lek; 7.3 is 28% above the six-year mean of 5.7. Known active lek locations are shown in Figure 5.

2001: Booming activity was observed by department personnel again in Decatur, Ringgold and Wayne Counties in 2001 (Table 2). Birds were active on seven booming grounds, an increase of one site (16.6%) from the previous year. However, the number of booming males dropped to 28 in 2001, a 36.4% decline from 2000 and a 16.7% decline

from the seven-year mean total of 33.6. The 2001 mean of four males per lek represented a 45.2% decline from 2000. Known active lek locations are shown in figure 5.

2002: This year personnel witnessed a direct loss of one lek in Ringgold Co. (69N, 29W, Sec 3) from previous years due to CRP conversion to rowcrop, but yet maintained seven active leks as in 2001. This is the third year for Decatur, Ringgold, and Wayne counties. Three new locations were found. However, the number of booming males fell again this year (21.4%) to 22, bringing the mean total to 37.0 (Table 2). This also continues a two year trend of declining males per lek to 3.1 in 2002. This year the number of leks is near average, but the count of booming males and mean males per lek is below the eight year mean at 59.5% and 52.5% respectfully. Current and prior lek locations are shown in figure 5. There were no releases or relocates done in 2002.

Figure 5. Locations of past and active prairie chicken leks in Iowa.



DISCUSSION

Prairie chicken reintroduction efforts initiated in Iowa in 1987 and in Missouri in 1993 have resulted in a small, somewhat stable population of prairie chickens across a wide area of southern Iowa and northern Missouri. Large areas of habitat in this area still lack prairie chickens, and additional stocking may help fill in the gaps and augment existing local populations. Proposed stockings in Iowa would include releasing additional hens onto all known booming grounds and establishing new release sites in suitable habitat.

Pasture and hay are still primary land uses in this region. This land use, coupled with a high sign-up in recent CRP programs, should assure adequate grassland habitat for several years. A positive aspect of recent CRP programs was the emphasis on establishing cover beneficial to wildlife instead of grass monocultures. The Wildlife Habitat Incentives Program (WHIP) of the USDA also targets improvement of prairie chicken

habitat in south central Iowa and should be beneficial to improving prairie chicken populations. Intensive management of large blocks of grassland by public agencies will help insure adequate habitat into the future. The Ringgold Wildlife Area has 300 ha which is managed as grasslands with open landscapes. Although no booming grounds have been located on this area in recent years, broods have been sighted nearly every summer.

Kellerton Bird Conservation Area/Grand River WHIP Update

A model for landscape-level grassland bird conservation was developed by research biologists in the Midwest and serves as the basic design for Partners in Flight (PIF) grassland Bird Conservation Areas (BCA). The Kellerton Bird Conservation Area (KBCA) was formally designated in 2001 and is PIF's first attempt to put the habitat objectives of the Dissected Till Plains Bird Conservation Plan into action. The KBCA is a 10,000-acre area of public and private lands located in extreme south central Iowa.

In 1998, the KBCA consisted of 70% grassland, 25% cropland, and 5% woodland. At least three current or recently used booming grounds are located within the boundaries. All the land was privately owned, and the grasslands were either pasture, hayfields, or land entered in CRP. Within this 10,000-acre area, a contiguous block of 2,100 acres of grassland was identified as a priority acquisition tract. The total estimated cost of this acquisition based on 1998 prices was $2,000,000. For this reason, acquisition of the 2,100-acre core area was proposed to occur in increments.

A 680-acre parcel was the first desired purchase aimed to protect Iowa's largest greater prairie chicken lek. The cost was $530,000. Unfortunately, the IDNR could not move quickly enough to acquire the 680 acres, and the land was bought by Kellerton Farms, a corporate farming group. However, because of a slump in commodity prices, Kellerton Farms decided to offer the property to the IDNR. The IDNR acquired the initial 680-acre KBCA tract in December 1998. The IDNR, the National Fish and Wildlife Foundation, Pheasants Forever, Iowa Audubon, and numerous private donations provided funds for the initial acquisition. An additional 58-acre tract was acquired in 2001, bringing public lands in KBCA to 738 acres.

In 2001, two broods of prairie chickens, with at least a dozen young per brood, were observed 1.5 miles north of the core public lands, and within the larger designated KBCA.

In addition to the proposed 2,000 acre publicly-owned core area, IDNR and the Natural Resource Conservation Service (NRCS) promote conservation efforts on nearby private land. WHIP and CRP programs can be used to enhance wildlife management on an additional 2,500 acres of land within the KBCA by encouraging farmers to use rotational grazing, cutting trees, and planting native grasses. IDNR's Upland Wildlife Biologist and Area Wildlife Manager work with local NRCS staff to promote WHIP and CRP among area farmers, with emphasis specifically given to the aforementioned land practices. Approximately 100 acres has been improved under

WHIP in 2001-2002, employing tree removal, local ecotype prairie seedings and prescribed burning.

The KBCA is the first grassland implementation of the PIF-BCA concept in the country. Wildlife Biologist Mel Moe implemented a management plan that includes a viewing area for prairie chickens. An old osage orange hedge row was cut in the spring of 1999 to open the vista of the new area, and a viewing platform and spotting scope were added in 2000. Large portions of the area continue to be managed for native grasses. Approximately 100 acres of cropland were converted to mixed native seedings in 2000 and 2001, with additional conversions planned for the future.

In addition to the KBCA acquisition, the Missouri Nature Conservancy (TNC) purchased the 2,200acre Dunn Ranch in the spring of 1999. The MDC also acquired Pawnee Prairie, a large grassland tract west of the Dunn Ranch. The Missouri TNC and MDC may create the second BCA in the country with these acquisitions.

Acquisition of core grasslands in Iowa and Missouri has led to the development of the Grand River WHIP project. Under the original PIF-BCA concept, approximately 2,500 of private grasslands must also be manipulated to benefit grassland birds. The Grand River WHIP project is a joint proposal between the IDNR, MDC, and NRCS to target $6 million dollars over 5 years into the 70,000-acre core area surrounding the KBCA and Dunn Ranch grasslands. The funding will be used to assist producers implement rotational grazing systems, seed pastures to native species, and remove trees. Funds can also be used to supply materials for fencing and watering systems. The project is contingent upon Congress reauthorizing WHIP in the Agriculture Appropriations bill.

Currently, this 4,170-ha (10,300 acres) landscape is 70% grassland, 25% cropland and 5% woodland. The Iowa Department of Natural Resources is to acquire 830 ha (2,050 acres). CRP and Wildlife Habitat Incentives Program (WHIP) will be used to improve habitat on at least 1,000 ha (2,470 acres) of private land (Moe 1999)."

E. Conservation Measures in Other States

In Illinois, a remnant population of about 150 prairie-chickens has survived on 1,460 ha (3,600 acres) on PRSNA in Jasper and Marion Counties. Intensive research and conservation effort has been invested in conservation of prairie-chickens including population monitoring, predator control, restoration and management of habitat, and translocation of birds to alleviate inbreeding depression (Walk 2004). Previous efforts to conserve prairie-chicken populations included purchase of two areas totaling 1,783 ha (4,407 acres) in the 1940's. Prairie-chickens were extirpated in both areas by 1960, apparently because of multiple use programs (Westemeir 1985 in Walk 2004). Attempts to introduce prairie-chickens in Perry and Randolph counties in 1979 failed (Walk 2004).

In 2004, Walk authored an extensive document detailing needs for recovery of prairie-chickens in Illinois including detailed recommendations on a state-wide basis.

"In Wisconsin, about 10,000 ha of public lands are managed in whole or in part for Greater Prairie-Chickens (Anderson and Toepfer 1999, Keir 1999). The spring 1998 population was estimated at 1,200 birds (Westemeier and Gough 1999). A reintroduction of wild and pen-reared birds (1974-1978) was initially successful in the Crex Meadows Wildlife Area (Toepfer 1988), but the population was gone by 1992 due to habitat deterioration (Anderson and Toepfer 1999). Prairie-chicken research has been particularly active in Wisconsin, with the long-term efforts of Fred and Frances Hamerstrom (e.g., Hamerstrom and Hamerstrom 1973; see Anderson and Gawlik 1999). A population bottleneck of about 300 birds in 1969-1971 (Anderson and Toepfer 1999) is implicated in a 26% decrease in genetic diversity of the Wisconsin prairie-chicken population between 1951 and 1996-1999 (Bellinger et al. 2003).

Missouri has about 6,700 ha (16,550 acres) of publicly-owned prairie (Mechlin 1991). The spring 1998 statewide population was about 1,000 prairie-chickens (Westemeier and Gough 1999). Plans call for additional public acquisition of 3,077 ha (7,600 acres) of Greater Prairie-chicken habitat (Mechlin 1991). The Missouri Grasslands Coalition formed in 1998, soon after the prairie-chicken was listed in Missouri. The Missouri Department of Conservation is an integral support of the Coalition, whose membership includes natural resource agencies, private conservation groups and cooperating landowners. Grasslands Coalition members pool research and education efforts, personnel resources, and funding to implement habitat improvements in nine focus areas throughout the prairie-chicken range. Projects include tree removal to reduce fragmentation of grasslands, conversion of fescue (*Festuca elatior*) to wildlife-friendly grasses, prairie restoration and developing grazing systems compatible with grassland bird use. The combined aspects of working in partnership, the development of strategic plans, and the applicability of the work to a broad spectrum of grassland interests has enabled the Coalition to attract over $1 million in grants in four years (S. Gough, personal communication).

Prairie-chickens were extirpated from Indiana by 1972 (Mumford and Keller 1984). At present, Indiana is evaluating potential reintroduction sites, including the Kankakee Sands Project Area in northwestern Indiana (2,900 ha or 7,163 acres) and reclaimed strip mine lands in southwestern Indiana, which are roughly 100 km (60 miles) from the remnant Illinois population at PRSNA in Jasper County (Castrale 2001). Nearly 17,000 ha (42,000 acres) of reclaimed strip mine grassland occur in southwestern Indiana, including 7 sites with >1,000 ha (2,470 acres) of grassland (Bajema et al. 2001)" (Walk 2004).

F. Recovery Potential

"Throughout the species' range, suitable habitat limits the abundance and distribution of Greater Prairie-Chickens (see Svedarsky et al. 1999a). Prairie-chickens have also responded favorably to a number of conservation actions… including habitat establishment and management. Effective methods for controlling pheasants (as brood parasites and competitors) and predators have been established in Illinois (Westemeier 1988, Simpson and Esker 1997). Recently, much more effective protocols for capturing and releasing Greater Prairie-Chickens to augment or establish populations have been developed (Toepfer et al. 1988). Prairie-chickens are adaptable to a range of grassland types and readily utilize agricultural lands for many life history needs. **The recovery potential of this species is very good, and is limited only by human motivation to provide adequate habitat.**

Habitat establishment. There are numerous well-documented cases of Greater Prairie-Chickens increasing in abundance following creation of habitat… Prairie-chickens are found nesting as early as the second growing season following planting, and grasslands in their first growing season are valuable as brooding habitat (Svedarsky 1988, Kershner 2001). Extensive grasslands established by the Conservation Reserve Program have been colonized by Greater Prairie-Chickens in Colorado, Iowa, Minnesota, Nebraska, and South Dakota (Svedarsky et al. 2000). Incidentally, these five states have had stable or increasing prairie-chicken populations over the past 20 years. In contrast, prairie-chickens have declined in 5 of 6 states where significant CRP grasslands have not been available (Svedarsky et al. 2000)" (Walk 2004).

Habitat management. Prairie-chickens respond well to habitat management. In Iowa, tree removal was important in prairie-chicken habitat development (M. Moe 2004, personal communication). "In Illinois, "prairie-chickens have persisted on a very small habitat base for 30 years due to intensive management of these grasslands (Simpson and Esker 1997). Similarly, managers in Wisconsin have maintained stable populations of prairie-chickens for 50 years through active management of grasslands (Anderson and Toepfer 1999). Effective management regimes are discussed in detail below.

Translocation. Toepfer et al. (1990) evaluated 40 attempts to establish populations of prairie grouse (*Tympanuchus spp*.) since 1950. Almost all failed to establish persistent populations. Lack of suitable habitat at release sites, failure to account for dispersal patterns of this genus, and poor documentation of results were notable deficiencies.

Since 1985, successful translocations have been conducted in Colorado, Illinois, Iowa, Missouri, and North Dakota (Svedarsky et al. 1999a). These translocations involved large numbers of birds translocated over a several year period and/or release of birds during molting to reduce dispersal. Techniques for translocating prairie-chickens are discussed in detail below.

Species adaptability. The Greater Prairie-Chicken is a bird of the tallgrass prairie, and persists on large remnant fragments of this ecosystem in Kansas, Missouri, Nebraska, North Dakota, Oklahoma, and South Dakota (Svedarsky et al. 1999a). However, prairie-chickens will utilize a variety of grassland types. In Illinois, prairie-chickens thrived for nearly a century on the 'substitute prairie' created by redtop bentgrass meadows in southeastern Illinois (Westemeier 1985). In Wisconsin, forest clearing followed by fire resulted in extensive sedge (*Carex spp*.) and bluegrass (*Poa spp*.) regions where prairie-chickens have persisted for a century (Anderson and Toepfer 1999).

Greater Prairie-Chickens also readily utilize agricultural lands. Indeed, the introduction of grain to the tallgrass prairie was likely a major reason for the dramatic abundance of prairie-chickens following European settlement (Westemeier 1985, Svedarsky et al. 1999a)" (Walk 2004). In Iowa, prairie-chicken populations peaked after large portions of the prairie landscape was used for crop production. "The 'ecological patterning' model of prairie-chicken reserves, designed in Wisconsin (Hamerstom et al. 1957) and adopted in Illinois (Sanderson et al. 1973), consists of blocks of secure grassland habitat interspersed in an open space, agriculture and grassland matrix. The model depends upon prairie-chickens utilizing agricultural lands surrounding protected nesting habitat for brood-rearing, foraging and displaying.

Just as excessive conversion of prairie to cropland caused prairie-chicken declines from 1860-1900, agricultural intensification results in these lands providing fewer life history needs of prairie-chickens. In particular, brood-rearing habitat must now be created on reserves, effectively reducing the amount of nesting habitat they can provide (Simpson and Esker 1997). It has long been recognized that intensified agricultural land use would increase the size of reserves necessary to maintain an equal number of prairie-chickens (Yeatter 1943, Hamerstrom et al. 1957, Sanderson et al. 1973).

Habitat Suitability Index model. A habitat suitability index (HSI) model has been developed for the Greater Prairie-Chicken (Prose 1985). The model considers 520 ha (1,280 acres), located within 20.7 square km (8 square miles), in blocks >0.8 km (>0.5 mile) wide, as a minimum amount of prairie-chicken habitat. Only two life history requisites are included: winter food and nesting cover. Optimum winter food is provided by unharvested or untilled stubble of corn or sorghum within 1.6 km (1.0 mile) of nesting cover. Optimum nesting cover is defined as grassland, pasture and hayland, and herbaceous wetland habitat, with a visual obstruction reading (a measure of vegetation height and density; Robel et al. 1970b) of 2.0 to 3.0 dm at the beginning of the nesting season, within 1.6 km (1.0 mile) of winter food.

There are no published accounts of this HSI model being implemented, thus its validity cannot be evaluated. However, a number of problems are apparent. The model does not include any minimum viable population guidelines. The grassland area requirements were based on information from Illinois, Indiana, Michigan and North Dakota. Yet, Greater Prairie-Chickens have been extirpated from two of these states (Indian, Michigan) and rescued from extirpation by translocations in the other two states

(Illinois, North Dakota). This strongly suggests the HSI model grossly underestimates the spatial requirements of a viable population of Greater Prairie-Chickens.

V. Ecology & Management of Greater Prairie-chickens

A. Life History

General. The Greater Prairie-Chicken is a characteristic bird of tallgrass and mixed-grass prairie ecosystems. In historic times, prairie-chickens may have been somewhat migratory and mast in savanna and open woodlands may have been important winter foods. At present, prairie-chickens are generally considered residents throughout their range, and waste grain is a key winter food source. Populations often fluctuate greatly in response to habitat and environmental conditions. Nesting success and brood survival are generally the factors limiting population growth rates (Wisdom and Mills 1997).

Mating System. Greater Prairie-Chickens are an arena or "lek" breeding species, a rare mating system in birds. Males defend relatively small territories (50-300 m^2) aggregated on a lek (or "booming ground"). Booming grounds may range from 2-70 males, although 8 to 9 males is average. Few dominant males hold central territories, and perform 70-90% of copulations. To attract females, males perform an elaborate display involving erecting their pinnae, inflating their tympani, drooping their wings, and giving a deep, resonating sound ("*whhooo-doo-doooohh*"), or "booming," while stamping their feet. This booming sound can be heard >1.6 km (1 mile) in calm weather. A variety of other vocalizations (*cluck, whine, whoop, cackle*) and displays (flutter jumps, bowing, and aggressive displays among males) are made (summarized from Johnsgard 1983, 2002; Schroeder and Robb 1993)" (Walk 2004).

In Iowa, males attend leks from late October to the first half of June. In late winter, male attendance increases and displaying becomes more intense**.** Booming in Iowa is most intense from mid-March to mid-April, beginning at dawn until a few hours after sunrise (Moe 2004, personal communication). "A less intense display period typically occurs late in the afternoon. Females primarily attend leks from late-March to mid-April.

Nesting & brood-rearing. "Following copulation, females incubate eggs and raise the young without assistance from the male. Female prairie-chickens nest on the ground at well-drained sites. Nest sites are typically within 1.6 km (1 mile) of a lek (Hamerstrom and Hamerstrom 1973, Drobney and Sparrowe 1977). Females lay 1 egg per day in the nest; average clutch size in Illinois is 12.3 eggs (Yeatter 1943). Incubation lasts approximately 25 days, and hatching may take 1-2 days. Hatching success of eggs is normally ~90% (Yeatter 1943), but may decrease to <40% in inbred populations (Westemeier et al. 1998a). Hens will renest if first nests are destroyed, but are known to raise a single brood per season (Schroeder and Robb 1993).

Recently hatched prairie-chickens are precocial and leave the nest with the hen shortly after hatching. Females lead broods to secure habitat with foraging resources; young

broods typically move 0.3 km (0.2 mile) and older broods may move 2 km (1.2 miles) daily. Chicks move and locate food on their own, and are brooded by females frequently during the first 2 weeks. Chicks grow rapidly, and can perform weak flights by 2 weeks and strong flights of 35 m at 3 weeks. Broods break up when young birds are 80-84 days old (Schroeder and Robb 1993).

Foods & water. Prairie-chickens are known to eat leaves, buds, fruits, and seeds of a variety of plants, as well as invertebrates. For young prairie-chickens, access to an abundance of high-protein invertebrates is crucial for development. Yeatter (1943) found grasshoppers were a particularly important food item for juvenile prairie-chickens during summer, as were dewberries (*Rubus villosus*), wheat and other seeds. For adults during summer, plant matter makes up 90% of the diet, particularly seeds and fruits (Yeatter 1943). Through the winter, grain comprises up to 90% of the diet. Corn and sorghum are preferred grains [when feeding in an agricultural area]. Water from foods and dew is usually adequate for prairie-chickens, although drinking from ponds and livestock tanks has been observed (Schroeder and Robb 1993).

Survival. Nest success averages 44% for Greater Prairie-Chickens (Schroeder and Robb 1993)…Brood survival ranges from 15% to 65% (Baker 1953, Horak 1985, Svdarsky 1988). Together, nest success and brood survival are the most important determinants of prairie-chicken population growth rates (Wisdom and Mills 1997). Annually, 48% to 65% of females successfully produce a brood (Schroeder and Robb 1993). Annual survival rates range from 40% to 50% for yearlings and adults (Hamerstrom and Hamerstrom 1973).

Home range & movements. Relative to other gallinaceous birds, prairie grouse (*Tympanuchus spp*.) are highly mobile, and sustained flights of >11 km (7 miles) have been recorded. Home ranges and daily movements are considerably smaller during the summer than winter. In Kansas, adult males had home ranges of 32 ha (79 acres) in August, but 513 ha (1,267 acres) in March (Robel et al. 1970a). In Minnesota, prelaying female prairie-chickens had the largest home ranges (82 ha, 200 acres) whereas home ranges of hens with broods were 11 to 18 ha (27 to 44 acres; Svedarsky 1988).

Juveniles tend to disperse from their natal area in the spring, with female movements greatly exceeding those of males (Hamerstrom and Hamerstrom 1973, Halfmann 2002). Adults tend to show high fidelity to leks and nesting areas among years (Schroeder and Robb 1993). Hamerstrom and Hamerstrom (1949) reported a female recovered 47 km (29 miles) from her natal area during her first autumn, and Halfmann (2002) documented a hen dispersing 70 km (43 miles) to her first nesting site. In northwestern Minnesota, a brood of 4 chicks (three females, one male) had a one-year minimum polygon range of 2,700 km^2 (1,045 square miles; Toepfer and Rosenquist, unpublished data).

Although prairie-chickens are capable of such long-distance dispersal, birds typically move much shorter distances. In Wisconsin, less than 10% of juvenile females disperse >18 km (11 miles). For juvenile males, 85% disperse <3.2 km (2 miles; mean

= 2.3 km or 1.4 miles), whereas 65% of young females disperse >3.2 km (mean = 6.9 km or 4.3 miles). Considering juveniles that left their natal population, 65% terminate dispersal at the closest available subpopulation (Halfmann 2002). Only following seasons of high recruitment (or translocations) does dispersal appear great enough for prairie-chicken range expansion and colonization of new habitats (J. Toepfer, unpublished data; S. Simpson, personal communication).

B. Habitat & Habitat Management

Leks (booming grounds). Leks are typically situated in open areas with short or no vegetation. Frequently, booming grounds are on ridges or other elevations. These sites allow males to see and be seen by female prairie-chickens and predators. Habitats used for booming grounds include recently burned, heavily grazed and closely mowed grassland, tilled fields, soybean stubble, and wheat plantings" (Walk 2004). In Iowa, prairie-chickens are displaying on leks as early as late October through June 1. Primary booming activities occur on leks from March through May, with most intensive activity in late March through early April (M. Moe 2004, personal communication).

Lek sites are positively correlated with grassland and negatively correlated with forest and rowcrop land cover within 1.6 to 2.4 km (1 to 1.5 miles; Merrill et al. 1999, Niemuth 2000). Prairie-chickens also avoid lek sites near farmsteads, residential areas, and towns (Merrill et al. 1999). Leks in Illinois 1994-2001 were >0.4 km (0.25 mile) from public roads, although ~70% of the PRSNA landscape is within 0.4 km of a public road (J. Walk, personal observation).

Nesting. Nest sites of Greater Prairie-Chickens are usually in well-drained locations, relatively near booming grounds, in vegetation with a dense upright structure and residual litter. Nesting vegetation is a dynamic habitat created by periodic disturbance. Recently burned and heavily grazed areas provide too little litter and/or too little cover for nesting. Undisturbed sites with vegetation >1 m (39 inches) and excessive litter build-up are unsuitable for nesting (Yeatter 1943, Westemeier 1973, Kirsch 1974, Drobney and Sparrowe 1977, Westemeier and Buhnerkempe 1983, Buhnerkempe et al. 1984, Horak 1985). In Iowa, Moe (2004) indicates that good nesting habitat includes grass not more than 3.5 dm (14 inches) tall. Prose (1985) described optimal nesting habitat as grassland, hay/pasture or herbaceous wetland vegetation with a visual obstruction reading (VOR; Robel et al. 1970b) of 2.0 to 3.0 dm (8 to 12 inches). Vegetation with VOR less than 0.5 dm (2 inches) or greater than 5.0 dm (20 inches) is unsuitable as nesting habitat.

McKee et al. (1998) found success at nest sites with >25% litter cover was one-half success at sites with <25% litter cover. Nest success also declined when woody cover exceeded 5%, when forb cover was <5% and grass cover was <25%. Success was not related to distance to trees. Nests located in agricultural grasslands (e.g., hayfields) had significantly lower success than nests located in native prairies and mixed native-nonnative grass pastures (Ryan et al. 1998). Further, nesting success tended to be

lower in a prairie-agriculture mosaic landscape than a contiguous prairie landscape. Svedarsky (1988) observed somewhat higher nest success in nonnative grasses (particularly smooth brome, *Bromus inermis*) than native grass habitats. This was due to more brush clumps in native habitats, which negatively affected nest success, as did excessive litter. In Illinois, nest success is lower in management units with higher nest densities (Buhnerkempe et al. 1984).

Suitable nesting habitat is apparently determined by vegetation structure, location and landscape context rather than plant species *per se* (Hamerstrom et al. 1957). Greater Prairie-Chickens readily nest in hayed, high-mowed, and lightly to moderately grazed native prairie grasses, and high-mowed, lightly grazed, and undisturbed non-native grasses (e.g., redtop bentgrass; timothy, *Phluem pratense*; smooth brome; bluegrass). Mowing, haying, grazing and prescribed burning have all been effective management tools for controlling vegetation height/density and litter build-up to provide prairie-chicken nesting habitat (Westemeier 1973, Kirsch 1974, Drobney and Sparrowe 1977, Westemeier and Buhnerkempe 1983, Buhnerkempe et al. 1984, Horak 1985, Svedarsky 1988, Svedarsky et al. 1999b).

Brood-rearing. Good prairie-chicken brood-rearing habitat offers considerable bare ground to allow easy movement for small chicks, overhead screening cover for protection from predators and direct sunlight, an abundance of invertebrate prey (particularly grasshoppers) for rapidly-growing young, within relatively close proximity to nesting habitat (Walk 2004). In Iowa, prairie-chickens were observed brood-rearing in course "weedy" vegetation (M. Moe 2004, personal communication) "In Illinois, broods of radio-tagged females were often located in newly seeded grass-legume fields, recently burned sites, and in annual weeds (Westemeier et al. 1995). Patches of brood habitat >4 ha (10 acres) were preferred over smaller plots. No-till soybean fields were frequently used by broods as well, but repeated spraying of agrochemicals in this habitat resulted in high brood mortality. Yeatter (1943) found broods in redtop meadows, small grains, fallow fields and field border habitats. In Missouri, Drobney and Sparrowe (1977) observed broods in small grains, prairie pastures, prairie hay, and legume fields. Horak (1985: 48) noted, "grassland is generally preferred by prairie-chickens, but there is a tendency for major brood activities to be associated with lands formerly or presently cultivated." He noted open, disturbed areas (overgrazed, field edges, cattle rubs) near tall escape vegetation were important brood sites. Edges of rowcrops, alfalfa and "go-back" areas (land reverting to grassland following cultivation) were considered excellent brood habitat in Kansas. Burning and moderate grazing were recommended to increase plant diversity (particularly of forbs) and increase insect abundance. At PRSNA, managers create brood habitat in the forms of new grass-legume plantings, recently burned areas, annual weed fields maintained by a 2-year tillage rotation, and overseeding legumes on tilled fire breaks (Simpson and Esker 1997).

Roosting. To a large extent, habitat suitable for nesting is suitable for roosting, although taller vegetation is utilized, particularly during harsh winter weather (Yeatter 1943, Hamerstrom et al. 1957, Kirsch 1974). In Missouri, the vast majority of roosting

occurs in prairie pastures (Drobney and Sparrowe 1977). Radio-tagged female prairie-chickens mostly roosted within grasslands in Illinois in the fall, winter and early spring, although cropland was primarily used during the day (Rubin 1994).

Foraging. Through the fall, winter and early spring, cropland is the overwhelmingly favored foraging habitat (Yeatter 1943, Hamerstrom et al. 1957, Drobney and Sparrowe 1977, Johnsgard 1983, Horak 1985, Rubin 1994). However, cultivated grains are perhaps not required for prairie-chicken winter survival, and native seeds and tree buds may be adequate winter foods (Prose 1985, Schroeder and Robb 1993). Kirsch (1974) advised against spending management resources to provide winter food. Sunflowers, corn, soybeans and sorghum are preferred in winter over small grains (Drobney and Sparrowe 1977, Schroeder and Robb 1993). Yeatter (1943) found corn, soybeans and weed seeds to be important winter foods in Illinois. Soybeans, however, are nutritionally inferior to other agricultural foods (Loesch and Kaminski 1989). Post-harvest tillage dramatically reduces waste grain available to wildlife in corn and soybean fields (Warner et al. 1985). During the breeding season, foraging habitat resembles brood habitat (Yeatter 1943, Drobney and Sparrowe 1977).

Loafing. Habitat used for loafing, a mid-day period of general inactivity, has been reported infrequently. Drobney and Sparrowe (1977) recorded most birds in prairie pastures in late winter, with prairie hay and legume fields becoming more important by late spring. Robel et al. (1970a) showed that short to mid-height grassland areas were frequently used at mid-day in all seasons, with higher use of grain fields during winter.

Escape cover. Drobney and Sparrowe (1977) determined escape cover after 383 observations of adult prairie-chickens flushing from various disturbances, and recording the cover type they next used. Cover 20 to 90 cm (8 to 36 inches) was used more than shorter vegetation, and cover <10 cm (4 inches) was not used. Prairie pastures were used as escape cover 46% of the time. Horak (1985) also noted the importance of tall escape cover near brood areas.

Landscape composition. Areas being considered for prairie-chicken management should be >30% grassland (Hamerstrom et al. 1957, Prose 1985). Horak (1985) considered 75% grassland and 25% cropland to be optimal prairie-chicken range. Prairie-chicken populations have been known to linger for a number of years in areas with as little as 15% grassland (Hamerstrom et al. 1957). Woodland is incompatible with prairie-chicken management, and linear woody vegetation, in particular, should be minimized to maintain open vistas and reduce predator abundance (Mechlin 1991, Sample and Mossman 1997, Simpson and Esker 1997, Fitzgerald et al. 2000).

Spatial considerations. Due to the mobility of Greater Prairie-Chickens, their large home ranges, and relatively low population densities, large areas are required to maintain prairie-chicken populations. At PRSNA in Illinois, the average spring density from 1963-1994 was 3.5 males/km^2 (9 males/square mile) in an area with about 20% permanent grassland (Simpson and Esker 1997). Although methods of estimating density vary, the Illinois figure is relatively high compared to other states; in Wisconsin

and Missouri for example, spring density estimates were nearer 2 males/km^2 (5 males/square mile). Densities occasionally approach 10 males/km^2 (25 males/square mile; Johnsgard 1983).

Greater Prairie-Chickens have also been reported to be "area sensitive," avoiding grassland patches smaller than some threshold level. Samson (1980) found prairie-chickens regularly only in prairie fragments >100 ha (250 acres) and within 40 km (25 miles) of another occupied prairie. Winter and Faaborg (1999) reported prairie-chickens were absent from prairie fragments <77 ha (190 acres) in Missouri. At PRSNA, prairie-chickens are most often associated with grassland tracts >40 ha (100 acres; Walk and Warner 1999).

Many prairie-chicken conservation plans were modeled after the "ecological patterning" plan of Hamerstrom et al. (1957). In this plan, a minimum of 1,295 ha (3,200 acres) of grassland habitat are maintained in a landscape with >20% permanent grassland, in blocks 16 to 65 ha (40 to 160 acres). This arrangement was hypothesized to support a greater number of prairie-chickens than a single block of habitat. The assumptions underlying this reserve design include (a) birds preferentially nesting within the protected grasslands and (b) utilizing the intervening agricultural matrix for foraging, brood-rearing, and other life history needs. Kirsch (1974) thought the minimum area necessary to support prairie-chickens was 520 ha (1,280 acres) within an area not to exceed 20.7 km^2 (8 square miles). Grasslands should be at least 65 ha (160 acres) and wider than 0.8 km (0.5 mile).

In designing PRSNA, Sanderson et al. (1973) thought 610 ha (1,500 acres) of nesting habitat in tracts 16 to 65 ha (40 to 160 acres) would sustain a population of 500 prairie-chickens. This pattern was to be duplicated in Jasper and Marion counties. These authors recognized that prairie-chickens in this "sanctuary" system would be heavily dependent upon surrounding agriculture, and that agricultural intensification would increase the amount of land necessary to provide brood habitat in addition to nesting habitat. Westemeier (1997) thought this objective was realistic if grasslands were "well-situated, properly managed, and well-used by the birds," but acknowledged as much as 1,600 ha (4,000 acres) may be necessary in each county to support 400-500 prairie-chickens.

In a similar scatter-pattern, or "mosaic," landscape in Missouri, prairie-chicken populations declined over a 27-year period, but were stable in a contiguous prairie landscape (Ryan et al. 1998). Further, nest success was lower in the mosaic landscape, primarily due to destruction of nests in agricultural lands (mainly hay fields). Prairie-chickens in the mosaic landscape had larger movements, larger brood movements, and lower survival compared to birds in a contiguous prairie landscape (Burger 1988, Ryan et al. 1998).

At present, scatter patterning is not considered the ideal prairie-chicken management plan in Missouri; rather, core grasslands of >520 ha (1, 280 acres) surrounded by additional scattered grassland tracts are desirable (Mechlin et al. 1999). In Wisconsin,

large grassland landscapes suitable for prairie-chickens are to be 4,050 to 20,250 ha (10,000 to 50,000 acres), with a 800-ha (2,000 acre) core grassland. At least 35% of the remaining landscape should be in permanent grassland cover such as pasture, prairie remnants and idle grassland; the remaining 52% can remain in crop production, ideally small grains and hay, with a minimum of forest cover (Sample and Mossman 1997). Similarly, Fitzgerald et al. (2000) advocate an 800-ha (2,000 acre) core grassland surrounded by a 4,000-ha (10,000 acre) matrix of at least 25% compatible grassland, 51% of which is in tracts >40 ha (100 acres). For the federally-endangered Attwater's Prairie-chicken in Texas, the goal is to de-list the subspecies when 5,000 birds are supported by 12,150 ha (30,000 acres) of managed grassland (U.S. Fish & Wildlife Service 1993). Simpson and Esker (1997), responding to the agricultural intensification predicted by Sanderson et al (1973) and the long-term decline and near-extirpation of prairie-chickens in Illinois by the early 1990s, revised land management goals for PRSNA. Current goals are 1,600 ha (4,000 acres) of grassland, in tracts >64 ha (160 acres), in both Jasper and Marion counties, each supporting a spring population of 500 prairie-chickens.

C. Minimum Viable Population, Metapopulation, & Source-Sink Population Considerations

Minimum viable population. A minimum viable population (MVP) is an estimated ideal population size that conservation biologists use to determine how many individuals are necessary in a population to have a certain probability of persisting for a certain length of time, given foreseeable demographic, genetic, and environmental stochasticity, or variation (Meffe and Carrol 1994). Models of MVP tend to show threshold levels: below certain levels, extinction risk increases dramatically and persistence time plummets. An MVP is thought to be 50 to 500 individuals (Brussard 1985).

Real populations often have the same genetic risks (inbreeding and drift) as smaller ideal populations upon which MVP estimates are based. This is particularly true in Greater Prairie-Chickens, with male-biased populations (1.1:1 to 1.6:1), lek-breeding system with few males successfully mating (10% to 40%), variance in reproductive success of females, and considerable annual variation in populations (Schroeder and Robb 1993). For prairie-chickens, the genetically effective population size is much smaller than the census population. A genetically effective MVP of 500 prairie-chickens may require a census population of 860 to >2,500 birds (Appendix I). In Wisconsin, a bottleneck of about 300 birds is implicated in a 26% loss of genetic diversity (Bellinger et al. 2003). A population bottleneck of <50 birds in Illinois resulted in a loss of genetic diversity and a reduction in egg hatchability from >95% to 38% (Bouzat et al. 1998a, b; Westemeier et al. 1998a).

Metapopulations. In Illinois, extirpation of small populations of prairie-chickens surrounding the Jasper County PRSNA grasslands has been implicated as a key demographic event that accelerated the loss of genetic diversity and fitness

(Westemeier et al. 1998a). This "metapopulation," a population of sub-populations, facilitates gene flow and counter-balances the effects of skewed sex ratios and local environmental variation (Brussard 1985). One of the key aspects of metapopulations is the periodic extinction and recolonization of areas" (Walk 2004). A metapopulation structure in southern Iowa and northern Missouri includes several populations presumably originating from different prairie-chicken lines in Kansas (M. Moe 2004, personal communication). A major population is located at Dunn Ranch in extreme northern Missouri. Known interaction among these populations located within 20 miles north and 20 miles south of the Iowa Missouri border (M. Moe 2004, personal communication) should reduce threats of genetic degradation within populations for some period of time.

***Source-Sink populations*.** "This concept is similar to metapopulation theory, but considers the key demographic rates (births, deaths, and movements of individuals) within subpopulations. In source populations, overall numbers may remain the same, but births exceed deaths, and individuals leave in search of other habitats. In sinks, deaths exceed births, and populations decline without an influx of "extra" individuals from source populations (Pulliam 1988). Counter-intuitively, overall population size (metapopulation size) may be larger in systems where most individuals are in sink habitats surrounding a source habitat, compared to a situation where only the source habitat exists with no available sink habitat (Pulliam 1988). As with metapopulation theory, source-sink dynamics suggest management of satellite population habitat for Greater Prairie-Chickens would increase overall and genetically-effective population size, and promote population stability.

D. Managing Interspecific Interactions

Humans. Managing people is an important consideration of Greater Prairie-Chicken populations. Hunting regulations or prohibitions are in place throughout the species' range, and in Illinois poaching is not perceived as a threat. Researchers are cautioned to avoid disturbing egg-laying and brood-rearing prairie-chickens (Westemeier and Gough 1999), although they are apparently tolerant of flushing during incubation (Westemeier et al. 1998b). Observers of the breeding displays at leks can also disrupt mating, requiring limitations on the number of visitors and frequency of visits to leks, as well as enforcement of "etiquette" among viewers (Sanderson et al. 1973, Simpson and Esker 1997). Even when restricted to roadsides and distances over 400 m (0.25 mile), concentrations of visitors sometimes cause prairie-chickens to cease displaying, and occasionally leave leks (J. Walk, personal observation).

***Competitors & Parasites*.** In the northern portion of the prairie-chicken's range, Sharp-tailed Grouse hybridize with and dominate interactions with Greater Prairie-Chickens (Schroeder and Robb 1993, Svedarsky et al. 1999a). In Illinois, the Ring-necked Pheasant is the most ecologically-similar species to the Greater Prairie-Chicken, and therefore most likely to seriously compete with the species (Buhnerkempe 1979). Male pheasants have been observed disrupting male prairie-chickens on leks, and female

pheasants lay their eggs in prairie-chicken nests (Vance and Westemeier 1979). Pheasant parasitism is problematic since their eggs require fewer incubation days than prairie-chicken eggs, resulting in prairie-chicken females abandoning many of their own eggs prior to hatching. Pheasant densities increased at PRSNA during the 1980s, and parasitism rates of prairie-chicken nests exceeded 40% (Westemeier et al. 1998c). Highly effective pheasant control methods have been established in Illinois (Westemeier 1988), resulting in the virtual elimination of parasitism by pheasants (Westemeier et al. 1998c). However, the prairie-chicken populations did not increase following pheasant control, suggesting other factors such as genetic inbreeding were limiting the population (Westemeier et al. 1998c).

Disease. To reduce the threat of disease being transferred from domestic birds to prairie-chickens, Simpson and Esker (1997) recommended put-and-take pheasant hunting areas not be developed within 50 km (30 miles) of grasslands managed for prairie-chickens. Following the dramatic decline of the Marion County prairie-chicken population as a nearby egg-laying facility began operation in 1987, Simpson and Esker (1997) advised that spreading domestic chicken manure on cropland near prairie-chicken habitat be eliminated.

***Predators*.** Methods of controlling mid-sized mammals, perceived as important prairie-chicken nest predators, have been established at PRSNA (Simpson and Esker 1997). Combined with elimination of den sites and wooded travel corridors, nesting success of ground-nesting birds is good at PRSNA (roughly 55%; E. Kershner and J. Walk, unpublished data). However, the prairie-chicken population did not increase after predator control was implemented, suggesting other factors have been limiting the population, such as brood survival, dispersal patterns, genetic inbreeding, or a combination of factors.

Besides mammals, other groups of predators can be important. Red-tailed Hawks (*Buteo jamaicensis*) and Great Horned Owls (*Bubo virginianus*) are abundant, potential predators of prairie-chickens (Yeatter 1943), although prairie-chickens avoid wooded edges preferred by these species. Elimination of wooded fencerows at PRSNA has further reduced the threat of these predators, although utility poles and fenceposts may serve has hunting perches. In Missouri, 60% of deaths of adult female prairie-chickens are caused by raptors (Burger 1988), and raptors are responsible for most deaths of incubating hens (J. Toepfer, and D. Wolfe, personal communications). Northern Harriers (*Circus cyaneus*) uncommonly prey on juvenile prairie-chickens and very rarely kill adults. However, harriers and Short-eared Owls (*Asio flammeus*) can be disruptive of booming male prairie-chickens (Westemeier 1986)…Cooper's Hawks (*Accipiter cooperi*) and Northern Goshawks (*A. gentilis*) may also be predators of adult prairie-chickens (Yeatter 1943, Schroeder and Robb 1993). Snakes are likely predators of eggs and young prairie-chickens (Yeatter 1943), although their importance has not been established.

E. Translocation & Reintroduction

Historically, translocations of *Tympanuchus* grouse have been notoriously unsuccessful (Toepfer et al. 1990, Schroeder and Robb 1993, Snyder et al. 1999). Most failed attempts have been due to too little habitat at the release site and failure to consider the dispersal capabilities of these birds. However, recently developed techniques have increased the probability of successful prairie-chicken translocations. As a result, several states have initiated translocation programs, creating a demand for prairie-chicken donors that exceeds supply. In general, requests to augment existing populations are favored over plans to establish new populations. Likewise, federally threatened or endangered populations are prioritized above unlisted populations (Prairie Grouse Technical Council 1999; Appendix II). For all translocations, specific, quantifiable management goals must be identified. Translocations must be monitored through radio telemetry, nest-brood-survival-dispersal studies and population surveys, particularly to identify causes of translocation failure. Thus future efforts will be more likely to succeed. Guidelines for translocations in Illinois are presented below, based on current knowledge. These guidelines will ensure that translocation efforts are a good investment of conservation resources that facilitate recovery of the Greater Prairie-Chicken in Illinois.

Existing populations. Translocations of prairie-chickens may be periodically necessary for small, isolated populations to counter genetic drift and inbreeding depression by mimicking natural dispersal. Exchange of eggs among populations may be effective (Westemeier et al. 1991). Problems associated with this include difficulty in locating candidate nests in each population, and the relatively small number of birds that are likely to be recruited into the breeding populations. Therefore, egg exchange is suitable for simulating dispersal to avoid genetic drift, but is not appropriate for critically small populations (<50 birds) that are in need of genetic and demographic 'rescue'" (Walk 2004).

Establishing new populations. Development of a prairie-chicken population on NSM requires the presence of several specific and different habitat types. Walk (2004) recommends that "… grasslands should be managed and evaluated as prairie-chicken nesting, brood-rearing, and roosting habitat for ≥3 years prior to reintroduction." He further recommends that for stable populations to be developed in Illinois, …"concurrent reintroductions at proximate (<20 km or 12 miles) locations and/or presence of potential satellite population habitat are highly desirable features to (1) retain some of the individual birds that disperse from release sites and (2) establish a metapopulation structure that increases the overall genetically effective population size and reduces demographic and environmental stochasticity" (Walk 2004).

NSM prairie-chicken introduction is best accomplished within a context of additional introductions in relatively nearby sites to maintain genetic vitality of the population. Prairie-chicken populations now established in southern Iowa and northern Missouri resulted from birds captured from several sites in Kansas, including some that were approximately 200 miles apart. As such, it is believed that the cluster of populations

includes adequate genetic diversity, precluding need for introduction of additional birds for a number of years (Moe 2004, personal communication).

The southern Iowa, northern Missouri metapopulation, however, is distant from NSM and at present does not fill the need for nearby prairie-chicken populations. However, there is interest within the Iowa DNR to develop prairie-chicken populations in other areas of the state (Moe 2004; Schlarbaum 2004, personal communications). An ideal situation could be to develop NSM as a centrally located prairie-chicken population in Iowa that could serve as a stepping stone to additional prairie-chicken populations, with introductions radiating out to other parts of the state. The most logical initial connection to make at this point would be between southern Iowa populations and NSM, with establishment attempts strategically located in key positions within the flight distance of prairie-chickens.

VI. Recovery in the Context of Ecological Restoration

A. Ecosystem Restoration & Management

NSM is a tallgrass prairie and savanna ecological restoration project, and not a single species management refuge. Thus, it is important to consider the impacts and consequences of prairie-chicken reintroduction to the broader goals and objectives of NSM ecological programming.

"Grumbine (1994) identified five specific goals of ecosystem management: maintaining viable populations of all native species, representing all native ecosystem types within protected areas, maintaining ecological processes such as natural disturbance regimes and water and nutrient cycles, protecting evolutionary potential, and accommodating human use within these constraints" (Walk 2004). Because NSM is an emulation of historic systems, refuge staff are concerned about reconstruction and restoration of historic condition as opposed to maintaining status quo. This requires an enormous effort and is best augmented with a powerful research and monitoring program to track changes, solve problems, and adaptively manage. Ecological restoration is made more difficult because 99.9% of the tallgrass prairie and savanna ecosystems in Iowa have been destroyed, reducing the number and quality of models for this project. In addition, NSM is the first landscape-scale attempt to emulate historic ecosystems on former farmland. It is a prototype, testing the degree to which tallgrass prairie and savanna ecosystems can be reconstructed in essence "from scratch". In such situations, introductions such as the Greater Prairie-chicken must be accomplished within the context of prairie plantings, invertebrate management, hydrologic development and many other factors.

"Because the Greater Prairie-Chicken is a resident, wide-ranging species that uses a diversity of grassland habitats throughout its life cycle, this bird has been proposed as an "umbrella species. Conservation strategies that maintain viable prairie-chicken populations are likely to encompass the needs of many prairie species with smaller

home ranges and narrower habitat requirements (Simpson and Esker 1997, Fitzgerald et al. 2000)" (Walk 2004).

"From an ecosystem management perspective, recovery of prairie-chickens should be linked to tallgrass prairie restoration, managed with natural disturbance regimes (fire and grazing), to the extent possible" (Walk 2004).

"High mowing is the primary habitat manipulation tool utilized for prairie-chicken management in Illinois (Simpson and Esker 1997, Svedarsky et al. 1999a). For the Attwater's Prairie-Chicken in Texas, mowing is an "emergency" management tool, used only when fire and/or grazing cannot be used (U. S. Fish & Wildlife Service 1993). A representative, remnant tallgrass prairie ecosystem with natural disturbance regimes (fire and grazing by native bison) does not exist, although such a restoration is being attempted in Oklahoma (Smith 1996). Grazing with domestic cattle is an alternative practice consistent with the final goal of ecosystem management, accommodating human use" (Walk 2004).

B. Bird Species of Concern as Habitat Indicators

Aggressive landscape management for purposes of prairie-chicken habitat development can be incompatible with some plant and invertebrates of special concern, because such management employs a combination of mowing, burning, grazing and tillage (Walk 2004). In some cases, predator control is deemed necessary, impacting several species of mammals (Walk 2004). However, some species are considered indicators that a landscape is appropriate for prairie-chickens. Nesting and winter use of an area by Northern Harriers indicate roosting and nesting habitat for prairie-chickens. Upland Sandpipers nesting and brooding in an area indicates brood-rearing and nesting habitat for prairie-chickens. Use by Short-eared Owls for nesting and wintering indicate prairie-chicken brood-rearing and roosting habitat. Finally, Henslow's Sparrows indicate roosting and nesting habitat (Walk 2004). Primary and secondary indicator species and their sensitivities to grassland and landscape considerations are summarized in Table 3 taken from Walk (2004).

Many of these species have wintered and all have nested on the refuge at least sporadically in the last 13 years. As such, at least some areas of the refuge could provide appropriate habitat for prairie-chicken use.

Table 3. Species indicating potential greater prairie-chicken habitat

Habitat Type:				
Nesting	Brood-rearing	Roosting	Area	Landscape
SEOW	**UPSA**	**NOHA**	**UPSA**	**UPSA**
UPSA	SEOW	**HESP**	**HESP**	**SEOW**
NOHA		SEOW	NOHA	NOHA
HESP			SEOW	

(Primary indicator species are in bold-faced type)

Area refers to species that have been consistently reported from the Midwest as sensitive to grassland area, preferring or requiring larger habitats.

Landscape refers to species that are considered sensitive to landscape composition, preferring or requiring landscapes with high grassland land cover and a little or no woody vegetation.

Abbreviations:

HESP = Henslow's Sparrow, *Ammodramus henslowii*
NOHA = Northern Harrier, *Circus cyaneus*
SEOW = Short-eared Owl, *Asio flammeus*
UPSA = Upland Sandpiper, *Bartramia longicauda*

VII. Recovery - Definitions

"Significant population: a population averaging >200 individuals for >5 years

Geographically separate population: a population >20 km (12 miles) from another population [1]

Satellite population: a small population (<200 individuals) established by natural colonization, and linked by dispersal to other population(s)

Dispersal matrix: landscape within which prairie-chicken populations occur and through which individuals must navigate to disperse among populations; a matrix of open land uses (grassland, agriculture) facilitates dispersal, whereas woodland, forest, urban areas, and various human structures (utility transmission lines, towers, petroleum extraction infrastructure, wind turbines, etc.) inhibit prairie-chicken dispersal

Prairie-chicken Range: a large scale land unit (>100 km^2 or 39 square miles) for conserving a minimum viable population of Greater Prairie-Chickens. The center of a prairie-chicken range is a >50-km^2 (19 square mile) ***management landscape*** with the following properties:

[1] *Geographic separation* is not intended to imply *demographic or genetic isolation*. Rather, this model recognizes that large landscapes of contiguous, suitable prairie-chicken habitat are not realistic within Illinois into the foreseeable future based on modern agricultural practices and land use trends that are likely to continue.

1. ≥40% secure grassland land cover, >60% of which is in tracts >0.8 km (0.5 mile) wide and >65 ha (160 acres); grassland tracts exhibit a high degree of connectivity
2. ≥20% hay, pasture, small grains and fallow land cover
3. <10% woodland/forest land cover
4. <10% urban/residential/built-up, farmstead and road land cover
5. Up to 40% row crop land cover

The balance of the prairie-chicken range has similarly low woodland/forest and urban/residential land covers that are deleterious to prairie wildlife management and a high proportion of land cover in agricultural grasslands, cropland and other uses that have neutral or positive value for prairie wildlife. Land use in the prairie-chicken range will ensure the entire management landscape is highly functional for conserving prairie-chickens and prairie wildlife. The goal is to maintain a spring density of 4 males/km^2 (10.4 males/square mile) within the management landscape, or 2 males/km^2 (5.2 males/square mile) throughout the prairie-chicken range, and thus a spring population of 400 males (800 birds)" (Walk 2004)"

VIII. Conclusions and Recommendations

Prairie-chicken reintroduction to NSM has been identified as a long-term refuge goal in the refuge Masterplan (U.S. Fish and Wildlife Service 1992). Prairie-chickens historically occupied tallgrass prairie thoughout what is now Iowa, and thus emulation of the native landscape on NSM should provide appropriate habitat. Successful reintroductions by the Iowa DNR in Southern Iowa indicate that it is possible in this state.

Size. The NSM acquisition boundary is approximately 15 square miles or three square miles smaller than the management landscape recommended by the Walk (2004) for Illinois. Current NSM size is approximately 5,600 acres, or 13.4 square miles, or nearly 5.6 square miles smaller than recommended. However, prairie-chicken establishment has occurred successfully on smaller areas in southern Iowa (Moe 1999). Slightly more than 1,000 acres of the Kellerton Bird Conservation Area in southern Iowa is owned by the Iowa DNR, though the project target project size is 10,000 acres. Much of this larger acreage is private lands with landowners enrolled in Conservation Reserve Program (CRP) through the NRCS. However, prairie-chicken use is primarily limited to publicly owned land because characteristically, CRP land includes a woody component undesirable to prairie-chickens (M. Moe 2004, personal communication).

Roads and human habitation/use. Though Walk (2004) indicated that leks in Illinois were >0.4 km (0.25 mile) from public roads, Moe noted that in Iowa, leks can be located adjacent to and in close proximity to roads (M. Moe 2004, personal communication). It is possible that characteristics of the roads such as pavement vs. gravel, or density of traffic may influence lek distance from roads. Traffic typically is low on roads near leks in southern Iowa, and road surfaces are gravel. Human population density is also relatively low.

In contrast to southern Iowa, Highway 163 is a four lane, heavily trafficked highway essentially forming the northern boundary of the NSM. In addition, approximately 29.9 miles of paved or gravel roads occur on the refuge or are within a 0.4 km (0.25 mile) of the refuge. NSM is less than a mile from Prairie City to the northeast, and less than 20 miles east of the rapidly expanding urban Des Moines area. Though observations are inconclusive, it is possible that the greater traffic on roads, the proximity to a major highway, and traffic of visitors attracted to the Prairie Learning Center and the refuge tour loop may negatively affect lek selection near roads on NSM. If negative influence is assumed to be similar to that reported by Walk, a large portion of the refuge would be unavailable for prairie-chicken lek selection (see Figure 6).

Habitat. Basic considerations for good prairie-chicken habitat include a landscape devoid of isolated trees, woodlots, and fencerows. In Southern Iowa, Moe (2004, personal communication) indicated that the single activity that most improved Iowa DNR grassland as habitat for prairie-chickens was removal of trees, because it reduced major predators. At NSM, there are currently no areas that are farther than a half mile from trees (see Figure 7). Many areas support dense growths of trees that will need to be removed.

Some tree species on the refuge present special problems in tree removal and will take more intensive effort and more time to control. Examples include black locust (*Robinia pseudoacacia*) and silver poplar (*Populus alba*), both highly invasive clonal species, that are difficult to eradicate or control. At least 5 populations of black locust currently exist on the refuge, though 2 additional populations have been aggressively treated and nearly controlled. One large population of silver poplar exists on the refuge. Though the refuge is engaged in an intensive tree removal effort, completion of this project will likely take at least 10 years with current resources.

Not all of the refuge will ultimately be treeless, however. Approximately 30% of the current refuge landscape is or will be occupied by savanna, as mandated by the refuge Masterplan (U.S. Fish and Wildlife Service 1992). The savanna area is represented by a wedge shape with an apex approximately a quarter mile east of the Prairie Learning Center, and broadening to approximately a mile and a half wide at the southern end of the refuge. Walk (2004) indicates that historically, "…mast in savanna and open woodlands may have been important winter foods." As such, savanna management may not be utterly detrimental to prairie-chickens, and may in fact emulate some facet of historic winter prairie-chicken habitat.

Dinsmore (1994) indicates that fences, posts, and wires entangled and injured prairie-chickens in their low flight pattern. As a former agricultural landscape, the refuge has many exterior and interior fences. Though fences are actively being removed by staff, YCC crews, and volunteers, this job is enormous and will take several years to complete at the current rate.

Figure 6.

Figure 7

Moe (2004, personal communication) indicates that the negative effects of fence may be overestimated and based on earlier observations when prairie-chickens were more plentiful and/or perhaps were concentrated in a small area. Occasionally in this context, a prairie-chicken could fly into fence when the flock is startled. In fact, the Iowa DNR is currently fencing lek sites for grazing in preparation for future booming ground activities. High wires may be more detrimental to prairie-chickens (Moe 2004, personal communication). There are several utility wires including high voltage wires that cross the NSM. Many of these are for the foreseeable future, permanent features of the landscape.

Prairie-chickens are adaptable to various kinds of habitat that do not provide exact matches to historic conditions. They have thrived in low intensity agricultural landscapes, in exotic grasslands, and in prairie landscapes; however, there are some substantial differences in habitat characteristics needed for booming grounds, nesting, and brooding.

Lek Habitat. Leks need to have an open character devoid of trees. There are areas that are burned between early November and mid-May that are temporarily devoid of, or have sparse vegetation that could serve as lek sites. Agricultural areas are used in southern Iowa and northern Missouri as lek sites and thus, local cropland could also be attractive locally to prairie-chickens after harvest. Open areas also exist in first and second year plantings that are mowed approximately three times per season. Many of these areas exist near taller vegetation and may provide ideal lek potential to prairie-chickens. In addition, some areas of the bison/elk enclosure tend to be more heavily grazed than others, providing the possibility that leks could be selected in this area.

Lek selection is difficult to predict, however, and prairie-chickens may or may not use sites predicted or desired. They also tend to avoid leks near farmsteads, towns and residential areas and roads, further limiting the number of desirable lek sites.

Nesting Habitat. Nesting also seems to be more successful on sites with less than 25% litter cover. Currently a good fit for that scenario may be in 3 year old plantings, with a heavy preponderance of Canada wild rye, but with minimal duff. Depending on the season, duff has built up significantly on a five year old planting unless the area has been burned. Additional nesting sites could include weedy lowland areas not occupied by reed canary grass or second year plantings mowed high provided mowing did not destroy nests. Lightly grazed areas in the bison/elk enclosure could also be useful for nesting habitat. Mowing, haying, grazing and prescribed burning can be useful in nesting habitat development (Westemeir 1973, Kirsch 1974, Drobney and Sparrow 1977, Westemeir and Buhnerkemp 1983, Buhnerkempe et al. 1984, Horak 1985, Svedarsky 1988, Svedarsky et al. 1999b in Walk 2004).

Brooding Habitat. Brood rearing habitat requires bare ground for chicks to easily move in, cover above to screen from predators and direct sunlight, abundant invertebrates for food for growing chicks, and an area close to nesting habitat. An important food is grasshoppers. A planting with a high abundance of forbs such as

partridge pea (*Cassia fasciculata*) and other legumes could provide good cover, especially in 3-4 year old prairie plantings. Such areas tend to support numerous grasshoppers (Drobney 2004 personal observation) and an abundance of highly protenaceous seeds. Such an area could also satisfy needs of winter forage areas.

Impacts on Management. Prairie-chicken managers indicate that inclusion of prairie-chickens at NSM could impede our ability to most efficiently move toward our goal of tallgrass prairie and savanna ecological restoration (Ladd 2004). However it could be possible that certain areas of cool season exotic areas or croplands could be temporarily designated as management areas for specific needs of prairie-chickens. Considering the refuge is still less than the minimum size required for good prairie-chicken management, accelerating land acquisition could be an important component of a prairie-chicken reintroduction program.

***Partnerships*.** Because prairie-chickens are mobile and may choose off-refuge lands for some or all of their habitat needs, it is important to anticipate prairie-chicken introduction with a strong education and outreach program to begin the process of coalition building amongst potential local partners. Farmers may be willing to assist with prairie-chicken introduction by being sensitive to habitat needs on lands nearby the refuge. Nearby Prairie City, currently engaged in development of a prairie theme in the town and on adjacent roadways and potential bicycle trails, may become active advocates, drawing additional partners to the table. It will be important to develop stakeholders who can support long term prairie-chicken habitat.

Additional important partners include the Iowa DNR, County Conservation Boards (Jasper and others), NRCS, the COE (COE), The Nature Conservancy, Iowa Natural Heritage Foundation, Pheasants Forever, and others who may advocate habitat for prairie-chickens. Many of these organizations have contributed to development of the Chichaqua Bottoms project beginning three miles north of the northern end of the Walnut Creek headwaters. Walnut Creek runs through the refuge from the northwest to the southeast. If some tangible connection could be made to this project via the headwater area, an additional 8,000 acres could contribute to habitat needs. In addition, Lake Red Rock, three miles south of the south end of the refuge is an COE impoundment that includes 75,000 acres, some of which is prairie and exotic grassland (see Figure 8 in pocket attachment). Connecting these three projects would create approximately 100,000 acres of land in central Iowa that could greatly contribute to quality of life for local residents, and provide a much larger contiguous area for prairie-chicken introduction.

Final Summary

NSM is not currently appropriate for Greater Prairie-chicken introduction due to landscape features that relate negatively to prairie-chicken habitat (abundance of trees, proximity to roads and structures). Figure 9 summarizes negative influences on prairie-chicken habitat that currently exist on the refuge. Preparation for prairie-chicken

introduction on the refuge includes continued intensive tree removal in appropriate areas, acquisition of land especially in areas where bison and elk range are scheduled to be expanded, as grazing can be important in development of prairie-chicken habitat. In addition, monitoring, planning and partnership development need to occur.

Development of partnerships with refuge neighbors in prairie-chicken introduction is critical, as prairie chickens may not stay within refuge boundaries. Several factors off-refuge that negatively influence prairie chicken habitat are summarized in Figure 10. Local education, outreach, and partnership programs need to be developed to draw stakeholders to the table in advance of prairie-chicken introduction to maximize success. This is timely, as Prairie City, just beyond the northeast corner of the refuge, is beginning to move toward adopting tallgrass prairie as a theme for economic development.

Action should be taken to begin planning for prairie chicken introduction by developing a habitat monitoring phase as a part of the overall NSM Habitat Management Plan. Discussion among conservation organizations to develop a state-wide landscape plan for prairie-chicken recovery in Iowa should begin; this document could help in beginning the dialogue. Prairie-chickens are adaptable animals and with appropriate timing of introduction relative to educational and outreach efforts, refuge ecological development, and partnership development, introduction is likely to be successful.

Figure 9

Figure 10

Literature Cited

Anderson, R. K. and D. E. Gawlik. 1999. A tribute to the Hamerstroms. Pages 1-7 *in* W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie-chicken: a national outlook. Miscellaneous Publication 99-1999. Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul.

Anderson, R. K. and J. E. Toepfer. 1999. History, status, and management of the greater prairie-chicken in Wisconsin. Pages 39-58 *in* W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie-chicken: a national outlook. Miscellaneous Publication 99-1999. Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul.

Bajema, R. A., T. L. DeVault, P. E. Scott, and S. L. Lima. 2001. Reclaimed coal mine grasslands and their significance for Henslow's sparrows in the American Midwest. Auk 118: 422-431.

Baker, M. F. 1953. Prairie-chickens of Kansas. University of Kansas Museum of Natural History and State Biological Survey of Kansas. Miscellaneous Publication 5, Lawrence.

Basore, N. S., L. B. Best, and J. B. Wooley, Jr. 1987. Arthropod availability to pheasant broods in no-tillage field. Wildlife Society bulletin 15: 229-233.

Bellinger, R., J. A. Johnson, J. Toepfer, and P. Dunn. 2003. Loss of genetic variation in greater prairie-chickens following a population bottleneck in Wisconsin, U. S. A. Conservation Biology 17: 717-724.

Bohlen, H. D. 1989. The birds of Illinois. Indiana University Press, Bloomington.

Bouzat, J. L., H. H. Cheng, H. A. Lewin, R. L. Westemeier, J. D. Brawn, and K. N. Paige. 1998a. Genetic evaluation of a demographic bottleneck in the greater prairie-chicken. Conservation Biology 12: 836-843.

Bouzat, J. L., H. A. Lewin, and K. N. Paige. 1998b. The ghost of genetic diversity past: historical DNA analysis of the greater prairie-chicken. American Naturalist 152: 1-6.

Brussard, P. F. 1985. Minimum viable populations: how many are too few? Restoration & Management Notes 3: 21-25.

Buhnerkempe, J. E. 1979. Habitat utilization and partitioning within a community of nesting grassland birds. M. S. Thesis, Eastern Illinois University, Charleston.

Buhnerkempe, J. E., W. R. Edwards, D. R. Vance, and R. L. Westemeier. 1984. Effects of residual vegetation on prairie-chicken nest placement and success. Wildlife Society Bulletin 12: 382-386.

Burger, L. W. 1988. Movements, home range, and survival of female greater prairie-chickens in relation to habitat pattern. M.S. Thesis. University of Missouri, Columbia.

Calahane, V. H., C. Cottam, A. Leopold, and W. L. Finley. 1942. Report of the committee on bird protection, 1941. Auk 59: 286-300.

Castrale, J. S. 2001. Feasibility of restoring greater prairie-chickens to Indiana (draft). Indiana Division of Fish and Wildlife, Mitchell.

Christisen, D. M. 1969. National status and management of the greater prairie-chicken. North American Wildlife and Natural Resources Conference 34: 207-217.

Christisen, D. M. 1985. The greater prairie-chicken and Missouri's land-use patterns. Terrestrial Series No. 15. Missouri Department of Conservation. Jefferson City, Mo. 51 pp.

Dinsmore, J. J. 1994. A country so full of game. University of Iowa Press, Iowa City, IA.

Drobney, R. D. and R. D. Sparrowe. 1977. Land use relationships and movements of greater prairie-chickens in Missouri. Transactions of the Missouri Academy of Science 10-11: 146-160.

Ehresman, B.L. 1996. Greater Prairie-Chicken. Pages 130 – 131 in L. S. Jackson, C.A. Thompson, and J. A. Dinsmore, editors. The Iowa Breeding Bird Atlas. University of Iowa Press, Iowa City, Iowa, USA.

Fitzgerald, J. A., J. R. Herkert, and J. D. Brawn. 2000. Partners in Flight bird conservation plan for the Prairie Peninsula. Version 1.0. American Bird Conservancy; Partners in Flight.

Gough, S. 1990. Overview of the greater prairie-chicken status outside Missouri. Missouri Department of Conservation, Columbia.
Grumbine, R. E. 1994. What is ecosystem management? Conservation Biology 8: 27-38.

Halfmann, D. A. 2002. Natal dispersal of greater prairie-chickens in Wisconsin. M.S. Thesis. University of Wisconsin, Stevens-Point.

Hamerstrom, F.N., Jr. and F. Hamerstrom. 1949. Daily and seasonal movements of Wisconsin prairie-chickens. Auk 66: 312-337.

Hamerstrom, F. N., Jr., and R. Hamerstrom. 1973. The prairie-chicken in Wisconsin—highlights of a 22-year study of counts, behavior, movements, turnover, and habitat. Wisconsin Department of Natural Resources Technical Bulletin 64.

Hamerstrom, F.N., Jr., O. E. Mattson and F. Hamerstrom. 1957. A guide to prairie-chicken management. Wisconsin Conservation Department Technical Bulletin 15.

Hjertaas, D., S. Brechtel, R. Jones, R. Edwards, and C. Schroeder. 1993. National recovery plan for the greater prairie-chicken. Report No. 5. Recovery of Nationally Endangered Wildlife Committee, Ottawa.

Horak, G. J. 1985. Kansas prairie-chickens. Kansas Fish and Game Commission Wildlife Bulletin 3.

Illinois Department of Natural Resources. 2001. Strategic plan 2002. http://dnr.state.il.us/Strategic.htm.

Iowa Department of Natural Resources. 2003. Trends in Iowa Wildlife Population and Harvest.

Johnsgard, P. A. 1983. The grouse of the world. University of Nebraska Press, Lincoln.

Johnsgard, P. A. 2002. Grassland grouse and their conservation. Smithsonian Institution Press, Washington, D. C.

Keir, J. R. 1999. Prairie-chicken management in Wisconsin: an interagency perspective. Pages 59-62 *in* W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie-chicken: a national outlook. Miscellaneous Publication 99-1999. Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul.

Kent, T. H., and J. J. Dinsmore. 1996. Birds in Iowa. Published by the authors. Iowa City and Ames, IA.

Kershner, E. L. 2001. Conservation of grassland birds in an agricultural landscape: the importance of habitat availability and demography. Ph.D. Dissertation. University of Illinois, Urbana.

Kirsch, L. M. 1974. Habitat management considerations for prairie-chickens. Wildlife Society Bulletin 2: 124-129.

Ladd, Doug. 2004. Personal communication.

Loesch, C. R., and R. M. Kaminski. 1989. Winter body-weight patterns of female mallards fed agricultural seeds. Journal of Wildlife Management 53: 1081-1087.

McKee, G., M. R. Ryan, and L. M. Mechlin. 1998. Predicting greater prairie-chicken nest success from vegetation and landscape characteristics. Journal of Wildlife Management 62: 314-321.

Mechlin, J. M. 1991. Species management plan for the greater prairie-chicken in Missouri. Wildlife Division, Missouri Department of Conservation, Jefferson City.

Mechlin, J. M., R. W. Cannon, and D. M. Christisen. 1999. Status and management of the greater prairie-chicken in Missouri. Pages 129-142 *in* W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie-chicken: a national outlook. Miscellaneous Publication 99-1999. Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul.

Meffe, G. K. and C. R. Carrol. 1994. Principles of conservation biology. Sinauer Associates, Sunderland, MA.

Merrill, M. D., K. A. Chapman, K. A. Poiani, and B. Winter. 1999. Land-use patterns surrounding greater prairie-chicken leks in northwestern Minnesota. Journal of Wildlife Management 63: 189-198.

Moe, M. 1999. Status and management of the greater prairie-chicken in Iowa. Pages 123-128 *in* W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie-chicken: a national outlook. Miscellaneous Publication 99-1999. Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul.

Moe, M. 2004. Personal communication.

Mumford, R. E. and C. E. Keller. 1984. Birds of Indiana. Indiana University Press, Bloomington.

Niemuth, N. D. 2000. Land use and vegetation associated with greater prairie-chicken leks in an agricultural landscape. Journal of Wildlife Management 64: 278-286.

Prairie Grouse Technical Council. 1999. Guidelines for interagency prairie grouse translocation projects: trapping request protocols and prioritization of requests. Draft document.

Prose, B. L. 1985. Habitat suitability index models: greater prairie-chicken (multiple levels of resolution). U. S. Fish and Wildlife Service Biological Report 82(10.102).

Pulliam, H. R. 1988. Sources, sinks and population regulation. American Naturalist 132: 652-661.

Robel, R. J., J. N. Briggs, J. J. Cebula, N. J. Silvy, C. E. Viers, and P. G. Watt. 1970a. Greater prairie-chicken ranges, movements, and habitat usage in Kansas. Journal of Wildlife Management 34: 286-306.

Robel, R. J., J. N. Briggs, A. D. Dayton, and L. C. Hulbert. 1970b. Relationship between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management 23: 295-297.

Rodgers, R. 1983. Evaluation of the re-establishment potential of sharptailed grouse in western Kansas. Federal Aid Project No. W-23-R-20. Study No. 18. Job Q1. Kansas Fish and Game Commission. Pratt. 7pp. mimeo.

Rubin, C. S. 1994. Survival, movements and habitat use of female greater prairie-chickens translocated from Minnesota to Illinois. M. S. Thesis. University of Illinois, Urbana.

Ryan, M. R., L. W. Burger, Jr., and D. P. Jones. 1998. Breeding ecology of greater prairie-chickens (*Tympanuchus cupido*) in relation to prairie landscape configuration. American Midland Naturalist 140: 111-121.

Sample, D. W. and M. J. Mossman. 1997. Managing habitat for grassland birds: a guide for Wisconsin. Wisconsin Department of Natural Resources, Madison.

Samson, F. B. 1980. Island biogeography and the conservation of prairie birds. Proceedings of the North American Prairie Conference 7: 293-305.

Sanderson, G. C., R. L. Westemeier, and W. R. Edwards. 1973. Acquisition and management of prairie-chicken sanctuaries in Illinois. Pages 59-79 in W. D. Svedarsky and T. Wolfe, editors. The prairie-chicken in Minnesota. University of Minnesota, Crookston.

Schroeder, M. A. and L. A. Robb. 1993. Greater Prairie-Chicken. *In* The Birds of North America, No. 36. A. Poole, P. Stettenheim and F. Gill, editors. The Academy of Natural Sciences, Philadelphia; The American Ornithologists' Union, Washington, D. C.

Sharp, W. M. 1957. Social and range dominance in gallinaceous birds—pheasants and prairie grouse. Journal of Wildlife Management 21: 242-244.

Simpson, S. A. and T. L. Esker. 1997. Prairie Ridge State Natural Area habitat plan. Illinois Department of Natural Resources, Springfield.

Snyder, J. W., E. C. Pelren, and J. A. Crawford. 1999. Translocation histories of prairie grouse in the United States. Wildlife Society Bulletin 27: 428-432.

Smith, A. 1996. Big bluestem: journey into the tallgrass. The Nature Conservancy. Council Oaks Books, Tulsa, Oklahoma.

Stempel, M.E. and S. Rodgers Jr.. 1961. History of prairie-chickens in Iowa. Proceedings of the Iowa Academy of Science 68:314 – 322.

Svedarsky, W. D. 1988. Reproductive ecology of female greater prairie-chickens in Minnesota. Pages 193-239 *in* A. T. Bergerud and M. W. Gratson, editors. Adaptive

strategies and population ecology of northern grouse. Wildlife Management Institute, University of Minnesota Press, Minneapolis.

Svedarsky, W. D., R. H. Hier, and N. J. Silvy, editors. 1999a. The greater prairie-chicken: a national outlook. Miscellaneous Publication 99-1999. Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul.

Svedarsky, W. D., T. J. Wolfe, and J. E. Toepfer. 1999b. Status and management of the greater prairie-chicken in Minnesota. Pages 25-38 *in* W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie-chicken: a national outlook. Miscellaneous Publication 99-1999. Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul.

Svedarsky, W. D., R. L. Westemeier, R. J. Robel, S. Gough, and J. E. Toepfer. 2000. Status and management of the greater prairie-chicken in North America. Wildlife Biology 6: 277-284.

Toepfer. J. E. 1988. Ecology of the greater prairie-chicken as related to reintroductions. Ph.D. Dissertation. Montana State University, Bozeman.

Toepfer, J. E., R. L. Eng, and R. K. Anderson. 1990. Translocating prairie grouse: what have we learned? Pages 569-579 *in* Transactions of the 55th North American Wildlife and Natural Resources Conference.

Toepfer, J. E., J. A. Newell, and J. Monarch. 1988. A method for trapping prairie grouse hens on display grounds. Pages 21-23 in A. J. Bjugstad, editor. Prairie-chickens on the Sheyenne Grasslands. U. S. Department of Agriculture Forest Service, General Technical Report RM-159.

U. S. Fish & Wildlife Service. 1992. Walnut Creek National Wildlife Refuge Masterplan. (Currently Neal Smith National Wildlife Refuge).

U. S. Fish & Wildlife Service. 1993. Attwater's prairie-chicken (revised) recovery plan. Albuquerque, NM.

Vance, D. R. and R. L. Westemeier. 1979. Interactions of pheasants and prairie-chickens in Illinois. Wildlife Society Bulletin 7: 221-225.

Walk, J. W. and R. E. Warner. 1999. Effects of habitat area on the occurrence of grassland birds in Illinois. American Midland Naturalist 141: 339-344.

Warner, R. E., S. P. Havera, and L. M. David. 1985. Effects of autumn tillage systems on corn and soybean harvest residues in Illinois. Journal of Wildlife Management 49: 185-190.

Warner, R. E., P. C. Mankin, L. M. David, and S. L. Etter. 1999. Declining survival of ring-necked pheasant chicks in Illinois during the late 1900s. Journal of Wildlife Management 63: 705-710.

Westemeier. R. L. 1973. Prescribed burning in grassland management for prairie-chickens. Proceedings of the Tall Timbers Fire Ecology Conference 12: 317-338.

Westemeier, R. L. 1980. Greater prairie-chicken status and management, 1968-1979. Pages 8-17 *in* P. A. Vohs and F. L. Knopf, editors. Proceedings of the Prairie Grouse Symposium. Oklahoma State University, Stillwater.

Westemeier, R. L. 1985. The history of prairie-chickens and their management in Illinois. Pages 17-27 *in* R. W. McCluggage, editor. Selected papers in Illinois History 1983. Fourth Annual Illinois History Symposium of the Illinois State Historical Society, Springfield.

Westemeier, R. L 1986. Endangered prairie-chickens and some species interactions. Illinois Natural History Survey Reports 262: 1-2.

Westemeier R. L. 1988. An evaluation of methods for controlling pheasants on Illinois prairie-chicken sanctuaries. Pages 267-288 *in* D. L .Hallett, W. R. Edwards, and G. V. Burger, editors. Pheasants: Symptoms of wildlife problems on agricultural lands. North Central Section of The Wildlife Society, Bloomington, IN.

Westemeier, R. L. 1997. Grassland for prairie-chickens: how much is enough? Illinois Natural History Survey Reports 343: 1-2.

Westemeier, R. L., J. D. Brawn. S. A. Simpson, T. L. Esker, R. W. Jansen, J. W. Walk, E. L. Kershner, J. L. Bouzat, and K. N. Paige. 1998a. Tracking the long-term decline and recovery of an isolated population. Science 282: 1695-1698.

Westemeier, R. L. and J. E. Buhnerkempe. 1983. Responses of nesting wildlife to prairie grass management on prairie-chicken sanctuaries in Illinois. Proceedings of the North American Prairie Conference 8: 39-46.

Westemeier, R. L., J. E. Buhnerkempe, and J. D. Brawn. 1998b. Effects of flushing nesting greater prairie-chickens in Illinois. Wilson Bulletin 110: 190-197.

Westemeier, R. L. J. E. Buhnerkempe, W. R. Edwards, J. D. Brawn, and S. A. Simpson. 1998c. Parasitism of greater prairie-chicken nests by ring-necked pheasants. Journal of Wildlife Management 62: 854-863.

Westemeier, R. L. and W. R. Edwards. 1987. Prairie-chickens: survival in the Midwest. Pages 119-131 *in* H. Kallman, editor. Restoring America's Wildlife 1937-1987. U. S. Fish and Wildlife Service, Washington, D. C.

Westemeier, R. L . and S. Gough. 1999. National outlook and conservation needs for greater prairie-chickens. Pages 169-187 *in* W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie-chicken: a national outlook. Miscellaneous Publication 99-1999. Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul.

Westemeier, R. L., R. W. Jansen, and S. A. Simpson. 1995. Nest and brood habitats used by translocated greater prairie-chickens in Illinois. Proceedings of the 21st Biennial Prairie Grouse Technical Council Meeting: 17.

Westemeier, R. L., S. A. Simpson, and D. A. Cooper. 1991. Successful exchange of prairie-chicken eggs between nests in two remnant populations. Wilson Bulletin 103: 717-720.

Westemeier, R. L., S. A. Simpson, and T. L. Esker. 1999. Status and management of the greater prairie-chicken in Illinois. Pages 143-152 *in* W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie-chicken: a national outlook. Miscellaneous Publication 99-1999. Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul.

Winter, M. and J. Faaborg. 1999. Patterns of area sensitivity in grassland-nesting birds. Conservation Biology 13: 1424-1436.

Wisdom, M. J. and L. S. Mills. 1997. Sensitivity analysis to guide population recovery: prairie-chickens as an example. Journal of Wildlife Management 61: 302-312.

Yeatter, R. E. 1943. The prairie-chicken in Illinois. Illinois Natural History Survey Bulletin 22: 377-416.